JOURNAL OF THE A·I·E·E·

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PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MEETINGS

of the

American Institute of Electrical Engineers

BALTIMORE REGIONAL MEETING, District No. 2 (April 17-20, 1928)

NEW HAVEN REGIONAL MEETING, Northeastern District No. 1 (May 9-12, 1928)

SUMMER CONVENTION, Denver, Colo. (June 25-29, 1928)

PACIFIC COAST CONVENTION, Spokane, Washington (August 28-31, 1928)

ATLANTA REGIONAL MEETING, Southern District No. 4 (October 29-31, 1928)

For Future Section Meetings, see notices in this issue

MEETINGS OF OTHER SOCIETIES

National Electric Light Association
Southeastern Division, Miami, Fla., April 11-14, 1928
Middle West Division, St. Louis, Mo., May 9-11, 1928

American Welding Society, Engineering Societies Building, New York, N. Y., April 25-27, 1928

American Electrochemical Society, Bridgeport, Conn., April 26-28, 1928

American Society of Mechanical Engineers, Pittsburgh, Pa., May 14-17, 1928

National Electric Light Association, Atlantic City, June 4-8, 1928

JOURNAL

OF THE

American Institute of Electrical Engineers

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JOURNAL OF THE A. I. E. E.

Devoted to the Advancement of the Theory and Practise of Electrical Engineering and the Allied Arts and Sciences

Vol. XLVII APRIL, 1928 Number 4

The Institute and the Student

For many years the Institute has taken a very active and helpful interest in students preparing for the profession of electrical engineering, and certain provisions made during the past few years have greatly increased the effectiveness of its participation in their development. Such provisions have been made because electrical engineering students of today will be leaders in the Institute of the future, and contacts formed now are of mutual advantage.

In 1925 the Board of Directors decided that there should be a Counselor for each Student Branch, chosen from members of the electrical engineering faculty who are also members of the Institute. The following year the Board authorized the organization of a Committee on Student Activities in each Geographical District, composed of the Vice-President, District Secretary, and all Counselors within the District, and the holding of an annual Conference on Student Activities with the traveling expenses of all members of this Committee and all incoming Chairmen of Branches within the District paid by the Institute at the rate of ten cents per mile, one way.

The first conference on Student Activities was held at the Pacific Coast Convention, Salt Lake City, in September 1926, and by special provision, it was a joint conference of the Pacific and North West Districts. Such conferences have been held in eight of the nine Geographical Districts in which Student Branches are located, and there have been two conferences by representatives of each of five Districts.

Many subjects concerning the various aspects of Student Branch activities have been discussed at these meetings, and the Counselors and Branch Chairmen have been most enthusiastic regarding the benefits derived. Previous to the holding of such meetings each Branch was largely an individual unit proceeding as it pleased in the choice of the activities in which it should engage. With the advent of the District Conferences, there came a determined effort in many parts of the country to define more clearly the principal functions of the Student Branches and to select those activities which will offer the greatest benefits to the students participating. There has been a tendency to "compare notes" rather intensively, and now each Branch can strive not only to meet its own local conditions in the best possible manner, but also gain from the experiences of others.

An outstanding result of the conferences has been an almost unanimous opinion that the principal function of the Student Branches is to develop the latent abilities of the students by affording opportunity to carry on activities similar to those of Institute members in the Section meetings and conventions; *viz.* the preparation, presentation, and discussion of papers, abstracts, reports, etc., on engineering and related subjects, with visits to places of engineering interest.

Thus the conferences on Student Activities, Student conventions, joint Section and Branch meetings, and the Branch meetings, themselves, offer much to the student who will participate actively in them. By the time his period of Student Enrolment expires, he can have a good knowledge of Institute activities and be in position to continue in such activities almost immediately.

It seems reasonable to believe that the Branch activities will become of increasing importance in the whole scheme of engineering education, since they offer opportunities for training in elements of leadership which are absolutely essential to real success in any division of engineering, and such opportunities cannot often be supplied so effectively by other means. The qualities which produce leadership in Branch work should constitute an excellent measure of the possibility of success in engineering organizations.

Some Leaders of the A. I. E. E.

Winder Elwell Goldsborough, manager of the Institute 1901-04 and vice-president 1904-06, is a member of a distinguished Maryland family, founded in 1670. His projenitors have included Robert Goldsborough, a member of the First Continental Congress, and Charles Goldsborough, Governor of Maryland.

Mr. Goldsborough was born in Baltimore in 1871 and when seven years old, went with his mother and his brothers to China where they joined his father, then a member of the United States Consular Service at Amoy. He traveled extensively with his father in China, Japan and Siam; in fact his interest in engineering first began when he was treated to the sight of the machinery of ocean liners and the United States war vessels, *Ranger* and *Monocacy*, along the China coast.

On his return to the United States, Mr. Goldsborough

attended Cornell University, from which he graduated in 1892. One of his most interesting experiences as a young engineer brought him in contact with the great men of the electrical profession at the International Electrical Congress at Chicago, 1893, at which von Helmholtz was in attendance.

In 1893 Mr. Goldsborough was at the head of the Electrical Engineering Department of the University of Arkansas, which he left to go to Purdue University in 1894. Here he was first an associate professor, and later, head professor of electrical engineering. While at Purdue, beside conducting scientific laboratory tests, which were made the subject of papers before the Institute, he was also engaged in making inspections and economy tests upon public utility plants. Also under the auspices of the electrical department of Purdue University, Professor Goldsborough had constructed by the Thordosen people of Chicago, a 1,000,000-volt, low-frequency transformer.

From 1902 to 1905 Mr. Goldsborough was Chief of the Department of Electricity of the St. Louis Exposition. The exposition of the science and practise of electricity at St. Louis was unique in that all of the instruments and machinery shown were connected up as working exhibits on a scale which admitted of the apparatus being tested both by committees of the Jury of Awards and by the Railway Test Commission. Professor Goldsborough was vice-president and assisted in the organization of the International Electrical Congress held in St. Louis during the Exposition, 1904, and had the pleasure of demonstrating the transformer before an evening assemblage of the Congress.

As Chairman of the Executive Committee of the Electric Railway Test Commission, a series of tests of electric railway equipment was made under his direction, the most important part of this work being the wind resistance tests carried out on a special interurban car and made on a straightaway portion of the roadbed of the Union Traction Company of Indiana at speeds up to 80 mi. per hour. A paper recently issued by the General Electric Company states that the data on wind resistance recorded at this time are the best now available from any source.

In 1905 Mr. Goldsborough joined the engineering and construction organization of J. G. White & Company as assistant to the president. For one of the projects investigated by him at this time, he arranged the financing, and was sent out to Denver, Colorado, to supervise and manage the work, which involved the engineering design and construction of three large dams and some 400 mi. of irrigation canals extending from the crest of the Rocky Mountains to the plains around Denver. One of these dams is the largest earth-filled dam in the United States. Some of the work was extremely heavy and most modern equipment of steam shovels, locomotives, and dump cars was used. Another phase of the development involved the purchase of something over 100,000 acres of land, about 12,000 acres of which were put under cultivation.

Later, Mr. Goldsborough managed and carried forward another extensive piece of construction work in Wyoming, at Laramie.

Returning East in 1914, he took up consulting engineering work in New York, until 1923 serving his clients in a variety of capacities. He did the work of organizing the movement which resulted in the development of the Mexican oil properties of the Atlantic Lobos Oil Company, now a subsidiary of the Atlantic Refining Company. This work was undertaken during the early stages of the War; nevertheless, it went forward, and the company built pipe lines, a railroad and extensive terminals in Mexico, and shipped as much as 1,300,000 barrels of oil per month.

Mr. Goldborough's main contribution as an engineer during the war was in the form of the organization of a large munition plant at Orange, Massachusetts, for the turning out of shells for the United States Government, the working being carried forward under the immediate auspices of the New Home Sewing Machine Co., of which, for the time being, Mr. Goldsborough acted as general manager.

Since 1923, Mr. Goldsborough has been with Henry L. Doherty & Company of New York, on special engineering work. His association with Mr. Henry L. Doherty began back in 1898 when they were members of a committee of the National Electric Light Association on Arc Light Photometry. In this early work, what were then very advanced photometric methods were developed and made the subject of papers before the National Electric Light Association. The new work now being undertaken relates to certain important new developments of which more may be heard later.

For work in electrical engineering, Mr. Goldsborough has received the decoration of the Order of the Crown of Italy from King Victor Emanuel. He is a Fellow of the Institute and at various times has been elected to membership in the following societies: American Society of Mechanical Engineers, Institution of Electrical Engineers of England, Franklin Institute, International Association for Testing Materials, Society for the Promotion of Engineering Education, and the American Association for the Advancement of Science.

Mr. Goldsborough served as a member of the Jury of Awards of the Buffalo Exposition in 1901, and as a member of the Superior Jury of Awards of the St. Louis Exposition in 1904. He has taken out numerous patents and is a writer of scientific papers. His recreations are golf and tennis and he has been elected to membership in the following clubs: Denver, University, Country and Transportation (Denver); St. Louis, Mercantile (St. Louis); New York Southern Society, Lawyers, Engineers, National Arts and Cornell (New York); and Country (South Norwalk, Connecticut).

Abridgment of

Loudspeakers of High Efficiency and Load Capacity

BY C. R. HANNA*

Associate, A. I. E. E.

***Synopsis.**—The design of high-quality horn-type loudspeakers with moving coil drivers is considered. Efficiency and maximum output capacity obtainable from this type of loudspeaker are calculated. Methods of providing load capacity greater than that possible with a single loudspeaker are described.*

* * * * *

I. INTRODUCTION

TWO very desirable properties in loudspeakers, besides fidelity of reproduction, are high efficiency and high output capacity. Efficiency is desirable not because power from the source (light socket or batteries) is costly, but because it means that a smaller power amplifier may be used. This greatly decreases the first cost and also the cost of maintenance. In the case of auditorium loudspeakers, high output capacity from the amplifier is obtained usually by the use of high plate potentials. For this reason, it is desirable to make it possible to use amplifiers of smaller rating with consequent lower voltages so that inexperienced operators may readily maintain them. In the case of a home loudspeaker, this is even more desirable.

High output capacity, of course, is more necessary for auditorium loudspeakers than for home loudspeakers. The average small loudspeaker, however, is not capable of radiating sufficient sound without overload when certain kinds of music are being reproduced, even for the home.

The purpose of this paper is to describe a high quality loudspeaker, the efficiency of which is many times that of the conventional type and of very large load capacity. The author is indebted to many other workers in this field for the great wealth of information that has been made available in recent years through publications.†

The new device combines the excellent radiating properties of the slowly expanding exponential horn having a large mouth[1] with the good electromechanical coupling of the electrodynamic or moving coil motor element. Both of these make for high efficiency. They also make for great load capacity; for, with a good radiating system, the diaphragm may be small and the motion of the diaphragm slight, making it fairly easy to prevent rattling; and with a moving coil drive, the force does not vary with displacement, eliminating a source of non-linearity common to moving iron types of drivers. It is likely that no other combination of radiating system and motor element has such possibilities of efficiency and load capacity.

II. DESCRIPTION AND DESIGN OF THE LOUDSPEAKER

a. The Horn. Before considering efficiency and load capacity, the design of a system which responds uniformly to a broad band of frequencies must be dealt with. It is well known that the exponential horn is a uniform radiator of sound for a given air velocity at its throat for all frequencies, from the highest down to a certain critical or cut-off frequency determined by the rate of expansion of the horn section.[1] If the equation of the horn is

$$A = A_0 \, \epsilon^{Bx} \tag{1}$$

the cut-off frequency is given by the relation

$$f = \frac{B\,a}{4\,\pi} \tag{2}$$

where a is the velocity of sound in air. If centimeter units are used for x, a should be in cm. per sec., or 34,400. Above this critical frequency, the radiation resistance at the throat of the horn rapidly approaches a constant value of

$$r = \rho\, a\, A_0 \tag{3}$$

where ρ is the density of air. The value of $\rho\, a$ is 41.2, this figure representing the mechanical impedance density in dynes/(cm./sec.), (or mechanical ohms), per sq. cm. of area at the throat of the horn.

The relation given above assumes that the horn is extended to a large area at the mouth so as to transmit the sound energy effectively to the atmosphere. In the paper to which reference is made, it was suggested that the diameter of the mouth (if of circular section) be

$$D = \frac{4}{B} \tag{4}$$

In terms of the wavelength corresponding to the cut-off frequency

$$D = \frac{\lambda}{\pi} \tag{5}$$

In practise, the mouth may be somewhat smaller without causing serious resonance effects. Horns of sections other than circular should have mouth areas equivalent to the above circle.

*Research Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

†For all references see Bibliography, complete paper.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Feb. 13-17, 1928. Complete copies upon request.

b. Mechanical Vibrating Systems. Fig. 1 shows one form of the new loudspeaker elements with the diaphragm placed alongside. Permanent magnets of cobalt steel supply the magnetic field. A piston or plunger-acting diaphragm with a flexible mounting, is chosen because it can be made to have only one resonance in the acoustic range of frequencies; *i. e.*, a lumped mass in combination with a lumped compliance has one resonance only. Flat diaphragms as used in the past have a number of resonance frequencies within the acoustic range because such diaphragms cannot act as plungers. To obtain this plunger motion, the central

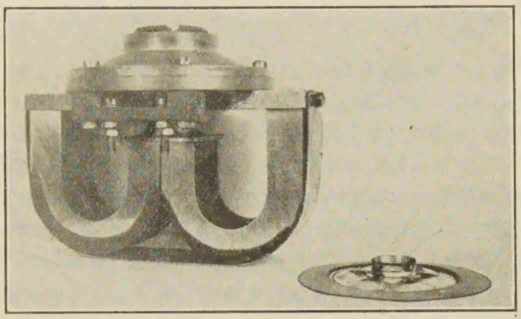

Fig. 1—Loudspeaker Element

portion of the diaphragm is stiffened by any of a number of methods of corrugation, while the edge is made very flexible either by mounting on an annular ring of rubber or by suitable corrugation of the metal at the periphery. In the diaphragm shown in Fig. 1, the shape is that of seven intersecting cones with a circular bead at the periphery for additional stiffening. Rubber is used for the flexible mounting.

The driving coil may be attached rigidly to the diaphragm, but it is better if an intervening resilient member of the correct stiffness is placed between the coil and diaphragm. In mechanical systems made up principally of masses and a mechanical resistance, better transmission of motion results if spring members are interposed between the separate masses in the chain.[4]

The diaphragm is made, of course, as thin as is consistent with internal rigidity. With most sizes and shapes of corrugated aluminum diaphragms, the thickness must be at least

$$t = 0.00035\, A_d \qquad (6)$$

(A_d = area of the diaphragm) to insure plunger action and adequate strength. The justification of the constant proportionality between thickness and area is that the fundamental resonance frequency of such diaphragms, considering the edge at rest, will be the same, assuming similar contours for all. This internal resonance must of necessity be above the highest frequency it is desired to reproduce, if the motion of the diaphragm is to be like that of the plunger. A fixed lower limit to this resonance frequency requires that the thickness shall not be less than a certain constant times the area.

If an air chamber transformer is used to step-up the velocity of the air on entering the horn, the mechanical impedance imposed on the diaphragm by the horn will be increased by the square of the transformation ratio

$$r = 41.2\, A_0 \left(\frac{A_d}{A_0} \right)^2 = 41.2\, \frac{A_d^2}{A_0} \qquad (7)$$

Thus, for a given area of diaphragm, the damping may be varied by varying A_0 and the correct value of damping is secured by proper choice of A_0[1]. The transformation from the large area of the diaphragm to the small area of the throat cannot be obtained physically without an air space immediately above the diaphragm. As previously pointed out,[1] this space must be small if the air displaced by the diaphragm is to be forced into the horn at the higher frequencies. Some of the volumetric displacement of air by the diaphragm must go to increase the pressure of air in the chamber and therefore this chamber is the equivalent of a mechanical capacity.[4] The stiffness of the air chamber referred to the diaphragm is obtained by considering its reaction on the diaphragm when the throat of the horn is closed. Assuming adiabatic changes, this stiffness, is

$$S_2 = \frac{1.4\, A_d^2}{V_0}\, p_0 \text{ dynes per cm.}^4 \qquad (8)$$

where V_0 is the air chamber volume and $p_0 = 1.01 \times 10^6$ dynes per cm.^{2}, or atmospheric pressure.

If the relation between the values of mass of diaphragm, mass of coil, the spring stiffness, air chamber stiffness and radiation damping is properly chosen, it is possible to obtain a device which responds uniformly to all frequencies from the lower cut-off of the horn to an

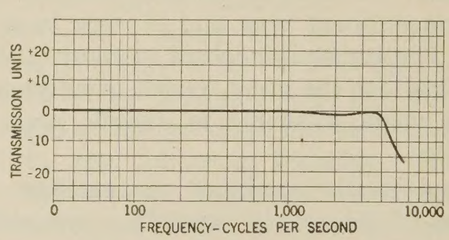

Fig. 2—Calculated Frequency Response

upper cut-off frequency which is determined by the mechanical system itself. The following relations hold for the design if this cut-off frequency is f_c:

$$s_1 = \pi^2 f_c^2\, m \qquad (9)$$

$$s_2 = 2\, \pi^2 f_c^2\, m \qquad (10)$$

$$r = \pi\, f_c\, m \qquad (11)$$

where m = mass of diaphragm = mass of coil

s_1 = stiffness of spider

s_2 = stiffness of air chamber

r = radiation damping due to horn.

Having chosen these quantities in this way, the response curve for $f_c = 5000$ will be as in Fig. 2, for a constant

driving force F, due to current in the moving coil. The equation of this curve is

$$W = 10^{-7}\frac{F^2}{r}$$

$$\frac{1}{1 + 16\left(\frac{f}{f_c}\right)^4 - 64\left(\frac{f}{f_c}\right)^6 + 64\left(\frac{f}{f_c}\right)^8} \text{ watts} \quad \textbf{(12)}$$

over most of the range $W = 10^{-7}\frac{F^2}{r}$. This relation does not take into account the falling off affect at low

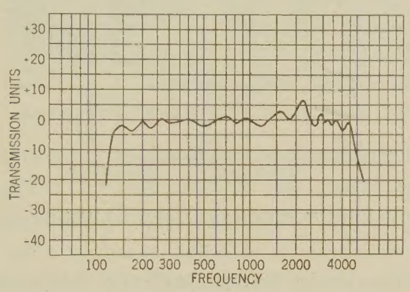

Fig. 3—Experimental Response Curve

frequencies caused by the stiffness of the diaphragm supporting member or the cut-off of the horn. Because of the fact that the moving coil-type of drive requires no stabilizing restoring force, as does the moving iron type, this edge stiffness may be made as small as desired. In like manner, if space permits the use of a large horn, the cut-off frequency of the horn may be made as low as desired.

Fig. 3 shows an experimental curve of response against frequencies for the loudspeaker of Fig. 1 when placed on a horn having a 100-cycle cut-off.

III. Calculation of Efficiency

By efficiency we shall mean the ratio of sound output to electrical input to the moving coil. The power required for field excitation if electromagnets are used will not be considered. The real advantage of high efficiency as above defined is that a great saving in amplifier capacity is effected. Although the field excitation power usually amounts to as much, or more, than the electrical input to the moving coil, it is conveniently obtained. Sufficient power for the voice coil, however, is not so easy to obtain.

It is shown in the unabridged paper that assuming that the whole mass of the coil is useful conducting material, the efficiency of loudspeakers of this type is:

$$N = \frac{1}{1 + 10^9\ \dfrac{\pi f_c \rho \delta}{B^2}} \quad \textbf{(19)}$$

where B = flux density in gap, gausses.
ρ = resistivity of conductor ohms/cm.[7]
δ = density of conductor gms./cm.[3].

The efficiency is seen to be independent of the size of the unit if the upper cut-off frequency, the flux density, and the mass conductivity of the coil are the same for all. High flux density and high mass conductivity (low $\rho\,\delta$) are needed. A field of 12,000 gausses is about as great as can be easily obtained. The value of $\rho\,\delta$ is smallest for aluminum being 7 by 10^{-6} as against 14 by 10^{-6} for copper. Curves of Fig. 4 show the efficiency of a 5000-cycle loudspeaker at different flux densities for both aluminum wire and copper wire coils. At 12,000 gausses the ultimate efficiencies are 57 and 40 per cent respectively.

In practical cases the coil form will not have a negligible mass; hence, a smaller amount of wire than mentioned above must be used. This is equivalent to an increase of $\rho\,\delta$ in equation **(19)** with a consequent reduction of N; however, efficiencies up to 40 per cent for aluminum wire and 30 per cent for copper wire are attainable.

It is interesting to compare these efficiencies with that of the best hornless loudspeakers of today. A calculation shows the latter to be less than 5 per cent in the range of frequencies up to about 1000 cycles. The gain in efficiency by using the horn results in a great saving in amplifier capacity.

IV. Load Capacity Determination

It might be expected that a loudspeaker of the type here described could be made to have a load capacity as great as desired by increasing its physical dimensions. If, however, the unit is to respond to the high frequencies, there is a very definite limit to the size of the unit, and therefore to the power which it may radiate without

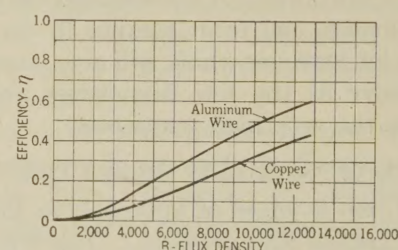

Fig. 4—Ultimate Efficiency of 5000-Cycle Loudspeaker for Different Densities

overload. In all cases, this maximum power is less for low frequencies because the maximum diaphragm velocity is smaller. This is due to the limited diaphragm displacement as determined by the clearance in the air cavity. Thus the figure for maximum power must always be accompanied by a statement of the frequency at which this limit is reached. Since for a given maximum diaphragm displacement the velocity is proportional to the frequency, and since the power radiated by the diaphragm is proportional to the square of the velocity, the maximum power output is proportional to the square of the frequency. Hence, if one watt is the load capacity of a given loudspeaker at 100 cycles, its capacity at 50 cycles will be only ¼

of a watt, while at 200 cycles, it will be 4 watts. The above reasoning falls down in cases where mechanical weakness of the moving parts is the limiting factor.

It is shown in the complete paper that the load capacity of this type of loudspeaker is dependent upon f, f_c, and A_0, in the following manner:

$$W = 609 \left(\frac{f}{f_c} \right)^2 A_0 \tag{24}$$

From this it is seen that a large orifice is desirable to give large amounts of sound output. With available materials for the diaphram, however, sufficient damping for obtaining a uniform response over the audio frequency range is secured only by the use of fairly small orifice areas. With an upper limit of A_0, therefore, there is a very definite upper limit of load capacity in a unit which responds uniformly up to f_c.

This upper limit of A_0 is found to be

$$A_0 = \frac{13900}{f_c} \tag{28}$$

Taking $f_c = 5000$

$$A_0 = 2.78 \text{ cm.}^2$$

It is seen that A_0 is definitely limited to this size no matter what diaphragm area may be chosen.

From equation (24), the maximum power for $f_c = 5000$ is definitely limited to

$$W = 0.68 \text{ by } 10^{-4} f^2 \tag{29}$$

At 100 cycles, $W = 0.68$ watt.

In view of the requirement of great power in the very low register for organ and drum reproduction, this limit is somewhat unfortunate. A knowledge of the limitation, however, prevents one from seeking in the dark for a single unit loudspeaker which will give larger outputs than the above at the low frequencies and still be responsive to the very high frequencies.

V. Methods of Obtaining Higher Load Capacity

There are two avenues of approach to the problem of obtaining greater load capacity. The first and most evident is to use a multiplicity of similar loudspeaker units as above designed, either on separate horns or on a single horn having a divided or multiple orifice. By this means, the load could be divided equally between the several elements and thus prevent overloading of any one of them. A second and more practical approach problem is based on the following reasoning:

It was noticed that the load capacity of a loudspeaker which responds to 5000 cycles was greater at higher frequencies, and it is possible that such a single-element loudspeaker would handle without overload the upper register of music and speech for very large amounts of power. If a supplementary loudspeaker, (or a group of loudspeakers), could be made to take care of large volumes in the lower register, the different bands of frequencies could be divided properly between the two by means of a suitable electrical network, and thus, a great increase in load capacity could be effected. From the relations already given (equation (24)), it is seen that loudspeaker elements which do not have to respond to the higher frequencies can be made to have greater load capacity. Hence, by making sturdier units with heavier diaphragms and larger air chamber volumes, the necessary load capacity for the low-frequency range can be secured.

To make use of an arrangement of this kind, it is necessary to devise an electrical network which will

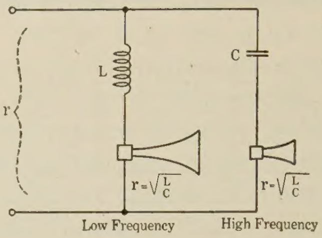

Fig. 6—Circuit Connection for Two-Element Loudspeaker

divide the frequency bands properly between the two loudspeaker elements. Of the many circuits which might be employed, the circuit shown in Fig. 6 was chosen because (a) it has constant impedance over the band of frequencies for which the loudspeakers are purely resistive in their impedance, and (b) because, for a given electrical input, the sum of the sound outputs of the two loudspeakers in the overlapping range is uniform. It is seen that the condenser in series with a small unit protects it from the damaging effect of large power at low frequencies, while the inductance in

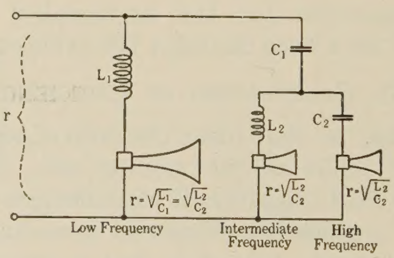

Fig. 7—Circuit Connection for Three-Element Loudspeaker

series with the low-frequency element prevents the higher frequencies from passing through this element which is incapable of responding to them.

In the case of a demand for capacity greater than is possible with two loudspeakers of different size, a third and larger element may be added. A simple circuit for three is shown in Fig. 7. This is seen to be an extension of the circuit of Fig. 6 by the insertion of a capacity in series with the square, paralleled with a series combination of large unit and inductance. This circuit may also be made to have constant impedance over the band of acoustic frequencies and by proper choice of the inductances and condensers, it may be

made to divide the frequencies between the several elements so as to secure the maximum over-all output capacity, as well as a uniform over-all response to a wide band of frequencies. Dr. J. Slepian, of the Westinghouse Research Laboratories, is responsible for the suggestion of this circuit.

It is evident that the use of two or more loudspeakers in this way is for an entirely different purpose from that

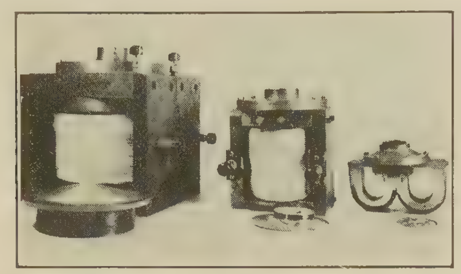

Fig. 8—Three Elements for Multiple Loudspeaker

of earlier attempts to secure a more uniform response to a wide band of frequencies by the use of several loudspeakers covering different ranges. In the present case, the small unit alone is capable of uniform response to a sufficiently wide band of acoustic frequencies for high-quality reproduction, but is found limited as to its output capacity for large power applications. The use of one or two supplementary loudspeakers with proper associated electrical network is made not to improve the quality of the reproduction, but to increase the output capacity. Each loudspeaker with its particular horn has a flat frequency response characteristic over a certain range, and in good designs, these ranges overlap considerably. The electrical network is what causes the tapering off of response of the individual loudspeakers in the overlapping range, so as to make the combined outputs uniform.

In order to make it responsive down to very low frequencies, it is necessary, of course, to have a large horn on the low-frequency element. The smaller elements, however, may be used in conjunction with smaller horns since the electrical network allows very little low-frequency current to pass through them with the result that they do not have to radiate low-frequency sounds.

Fig. 8 shows the three elements of a loudspeaker of this type, with their corresponding moving elements placed in front of each.

The writer desires to thank Dr. J. Slepian for valuable suggestions, and Mr. W. O. Osbon for carrying through much of the design work and for his contributions to the development.

A large number of engineers associated in the Midwest Power Conference is planning to go abroad on the International Power Tour. The party will sail from New York on August 18. While in Europe it will visit most of the large power plants and new developments in the various countries.

WHITE LIGHT VERSUS NORTH SKYLIGHT FOR COLOR-DISCRIMINATION

In the development of artificial lighting a propitious stage has been reached for exploding the tradition that north skylight is the best quality of light for the discrimination of color. In the past, when artificial light was entirely unsuitable for color-discrimination, those interested in color chose north skylight because it was more nearly constant in quantity and quality than light from any other region of the sky. Hence it has become traditional to consider it the standard of daylight. Unfortunately, this so-called standard is quite variable in intensity and spectral character from hour to hour and from day to day.

The illuminant most suitable for color-work is one which does not favor any particular color. White light is the only illuminant satisfactory in this respect. Spectrally, it is practically identical with noon sunlight on a clear day when the sun is at a high altitude. In white light the radiant energy is nearly equal in amount for all wavelengths throughout the visible spectrum. Since north skylight from a clear sky is quite bluish, it makes the purples (pink, lavender, magenta, etc.) appear more bluish than they would appear in white light. Because of its deficiency in yellow, orange and red, north skylight suppresses these colors in objects illuminated by it.

Those who developed artificial daylight found it necessary to supply a quality of light simulating north skylight because of the firmly intrenched habit of using north skylight for color-work. Here is one of the many cases where what people want and what is best are two different things. Inasmuch as color-discrimination does not involve taste, it seems that science rather than habit should dictate what an illuminant should be for general color-work.

To produce artificial north skylight with tungsten filament lamps it is necessary to absorb about 85 per cent of the light. However, to produce white-light corresponding to noon sunlight on a clear day in summer, an absorption of only 60 per cent is necessary. In other words, white-light—the only illuminant which is scientifically sound for color-discrimination—can be produced with tungsten lamps at nearly three times the efficiency of artificial north skylight.—Committee on Application and Production of Light.

Overproduction in the petroleum industry is causing such waste that The Federal Oil Conservation Board, has recommended that national legislation be enacted to curb this waste.

The Committee recommends that the proposed Federal legislation "shall unequivocally declare that agreements for the cooperative development and operation of single pools are not in violation of the Federal antitrust laws."

Abridgment of

Effect of Transient Conditions On Application of D-C. Compound Motors

BY LEON R. LUDWIG[1]

Non-member

***Synopsis.**—When a d-c. compound motor is started, the rise of current in the series field induces a voltage in the shunt field counter to that applied, and the shunt field current may reach several times normal value in a negative direction. This current reversal gives, in effect, a differentially compounded motor during the starting period and causes the starting torque to be materially reduced. In many applications of compound motors, therefore, predetermined performance is not obtained. In particular cases where the motor is continually started and stopped, the effect may be so serious as to dictate the choice of another type of motor or one of a special design to minimize the undesirable action.*

In case the compound motor is disconnected from the line while running and reconnected with no external resistance, the delay in establishing a flux due to the damping action of the shunt field may permit excessive currents to flow.

In other d-c. motors, currents induced in the solid iron portions of the frame and poles exert a damping effect similar to that of the shunt field in the compound motor, which may at times be undesirable. A study of such transients leads to means by which they may be minimized and provides calculation methods for predetermining motor behavior.

* * * * *

INTRODUCTION

IN the compound motor, there are two distinct electrical circuits linked by a common flux. The current changes during transient periods are therefore not inter-dependent, though in most motors the current in the shunt field is dependent largely upon the current change in the series field. In the series circuit, also, there is an induced voltage which depends on the flux linking the two coils as well as on the speed, which in turn is a function of the flux, series current, and time.

There is, in effect, a third closed electrical circuit consisting of the solid iron portions of the frame and poles, in which eddy currents flow, exerting an influence on the main flux.

The motor may be started with an initial current in

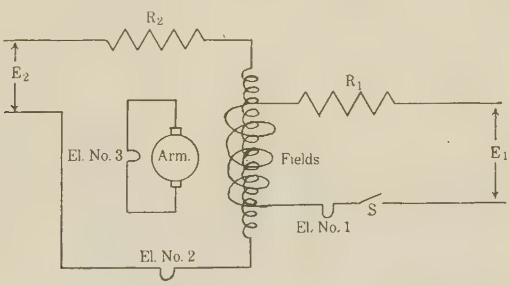

FIG. 1—DIAGRAM OF TEST CIRCUIT

the shunt field, or by closing both field circuits simultaneously. In either case, the rise of series field current will induce in both the shunt field and the solid iron a current tending to oppose the establishment of a flux. The induced voltage in the shunt field will be opposite to the impressed voltage and usually will be greater on account of the high transformer ratio between the fields. The shunt field current will usually reverse and restrain the flux from increasing as rapidly as the series current. Under such conditions, the starting torque would be less than with an equivalent straight-series motor.

The oscillogram in Fig. 2 was taken with a compound motor connected as in Fig. 1. The machine was driven externally at constant speed in order to obtain

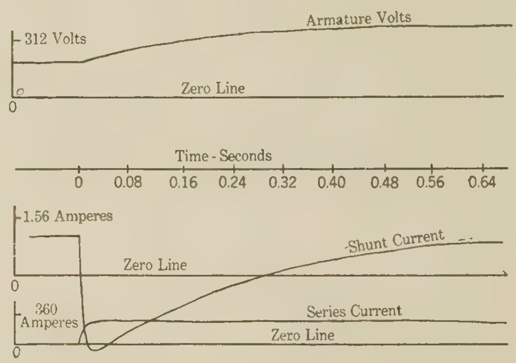

FIG. 2—CURRENT TRANSIENTS OBTAINED FROM TEST

the instantaneous field flux which is directly proportional to the armature voltage. The series current in this case rises inductively to a value limited only by the resistance, and the shunt current reverses, reaching a negative peak of 2.5 times normal. The flux increases very slowly. Another film (Fig. 3) was taken with the shunt field open-circuited. An initial current in the series field gave the same initial flux as in the first test, and this current was increased to the same final value. It will be seen that the flux rise is much more rapid, though it does not increase directly in proportion to the series current because of the solid iron damping.

The reduction of starting torque due to the shunt field damping is usually obviated by reducing the starting resistance in series with the motor. This procedure,

1. Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

however, causes the energy required for starting the machine to be increased, and also causes the motor current to reach a higher starting peak. The latter may cause sparking at the commutator and would be undesirable from a standpoint of contactor burning if the motor circuit were opened frequently very soon after the machine was started.

Transients in d-c. machines in general have been dealt with by K. L. Hansen in a paper presented at the Midwinter Convention of the A. I. E. E. in 1917, and

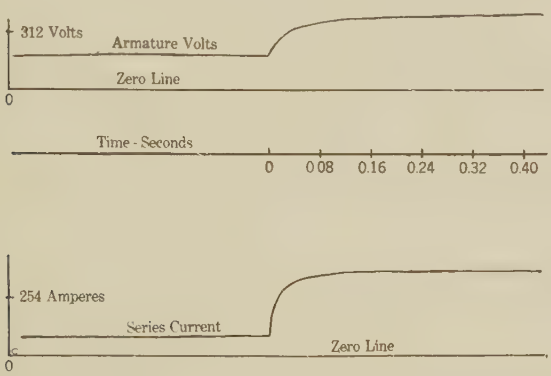

FIG. 3—CURRENT TRANSIENTS WITH NO-SHUNT FIELD

though the reversal of the shunt field current was cited in this paper, there was no attempt made at that time to find the exact effect of this reversal on the transient motor characteristic.

ANALYSIS OF TRANSIENT CURRENTS AND FLUX

In compound machines, most of the damping is because of the shunt field. It is possible also to take into account the effect of eddy currents in the iron by

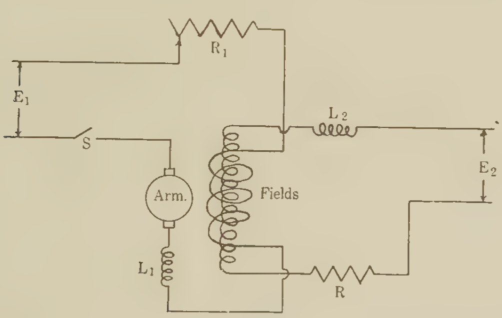

FIG. 4—DIAGRAM OF MOTOR CONNECTIONS

properly choosing the circuit constants, and the third electrical circuit may therefore be neglected. If i_1 is the series current and i_2 is the shunt current, neglecting saturation, the flux will be proportional to a fictitious current (i), which is expressed as

$$i = i_1 + a\, i_2$$

in which a is the ratio of the number of shunt field-turns to the series field-turns. Referring to Fig. 4, the two fundamental equations, will be:

$$E_1 = M \frac{d\,i}{d\,t} + L_1 \frac{d\,i_1}{d\,t} + R_1\, i_1 + e\, g$$

$$E_2 = a\, M \frac{d\,i}{d\,t} + L_2 \frac{d\,i_2}{d\,t} + R_2\, i_2$$

The generated voltage $e\,g$ must be expressed in terms of instantaneous speed and flux. The constant M is the coefficient of mutual inductance. L is the inductance due to the leakage flux linking the series field plus the armature inductance, and L_2 is the leakage inductance of the shunt field plus any external inductance.

The solution of these equations is given in the appendix, equations (I) and (II). In Fig. 5 the curves are plotted for the two currents, flux and torque, assuming

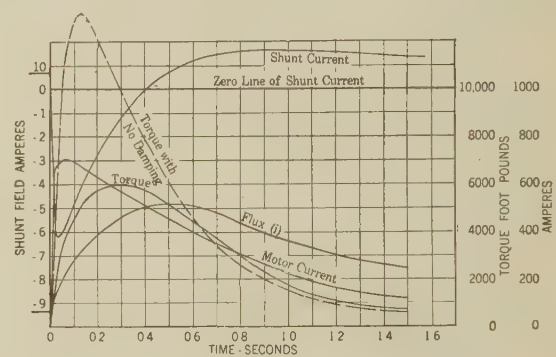

FIG. 5—CALCULATED TRANSIENT CURVES WITH MOTOR STARTING

that the motor is started with an initial shunt field. As shown by the curves, four-tenths of a second elapses before the shunt field ceases to handicap the series field. It is interesting to note that as the series current decreases when a counter e. m. f. is established, it causes the shunt current to become greater than normal in a positive direction.

From these curves, it is evident that a very short

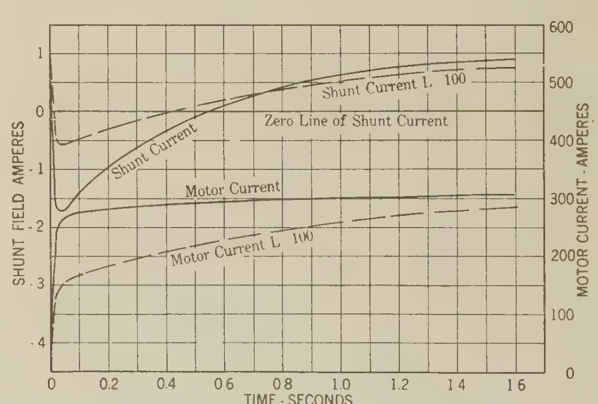

FIG. 6—CALCULATED TRANSIENT CURVES WITH MOTOR BLOCKED

time elapses before the currents reach their peak values. Since the magnitude of the damping is largely a function of these peak values, it is usually sufficient to obtain only the very early part of the transient in order to determine the effect of damping. The armature of the motor will not begin to rotate until after the current peaks are passed. It is, therefore, often

convenient to assume that the motor is blocked and that $e\,g$ in the equation is zero. A solution under this condition is given in the appendix equations (III) and (IV). The curves are plotted in Fig. 6, and compare with the test of Fig. 2 except that armature inductance was not in the circuit during the test. Furthermore, the affect of saturation was neglected in the calculations.

In case the motor is running and the circuit is opened and then closed before the speed has dropped appreciably, the term $e\,g$ is a function of flux only. Equations (V) and (VI) in the Appendix give this solution, and in Fig. 7, the curves are plotted. It was assumed

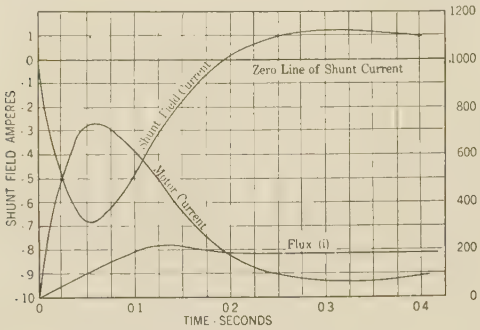

Fig. 7—Calculated Transient Curves with Motor Running and Circuit Closed

that the shunt and motor circuits were both opened and closed, or that no initial flux was present. In previous solutions, the transients were non-oscillatory; that is, there was no periodic pulsation of current. Under the present conditions, however, the constants must be nearly always such that the final solution contains sine and cosine terms. The phenomenon therefore resembles a condenser charge.

The load on the motor was assumed to be such that 100 amperes were required under steady-state conditions. The curve of series current during the oscillation decreases below 100 amperes, later regaining this value. The shunt current also oscillates past the steady-state value. The time for one cycle of the oscillation is about the same as that required for the transient to disappear.

Results of Current Transients

In order to find the quantitative reduction in starting torque resulting from the transients described, the curves in Fig. 5 may be compared with curves obtained from an ideally perfect case. This ideal case may be represented by a compound motor in which it is assumed that there is no interaction between the two fields. The shunt field current will remain constant at its initial value during the transient, if such an assumption is made. The fundamental voltage equation for the series circuit then becomes:

$$E_1 = L\frac{d\,i_1}{d\,t} + R_1\,i_1 + e\,g \qquad \text{(C)}$$

In this equation, L is the sum of L_1 and M. The curves of torque and current resulting from its solution (equation (VII), Appendix) are also plotted in Fig. 5. The maximum torque is more than twice as great as that obtained with damping. The average value of torque during the starting period, with damping, is 3250 ft-lb., and without damping is 4600 ft-lb., or the reversal of the shunt field current causes the torque to be decreased to 71 per cent of its value. The iron would saturate during the current peak, however, and the true torque would be less than 4600 ft-lb. if there were no field interaction.

An oscillogram was taken as a compound motor was started with a shunt generator for load. The curves in Fig. 9 are an analysis of this oscillogram showing how the total input power is divided in the motor. The accelerating power was calculated from the moment of inertia and instantaneous speed. The losses due directly to field interaction are included in the load loss curve. Actually, the additional current necessary to provide a given starting torque with a weakened field gives rise to additional and unnecessary copper loss. The curve of "essential input" is the sum of the actual required power, and the area between the two input curves is the loss which may be charged to field interaction. This loss is within the motor itself and does not include the additional loss incurred in the starting resistance because of field interaction.

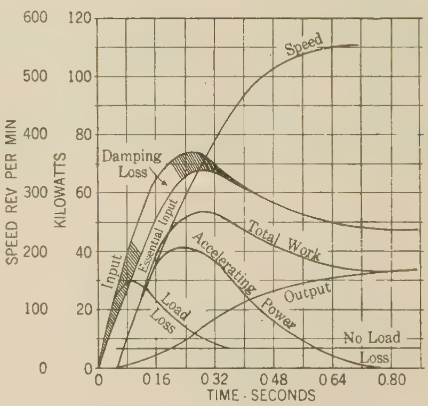

Fig. 9—Curves Plotted from Test of Motor Starting

The peak of starting current is a function of generated voltage at the time of the peak. With no field interaction, and consequently a higher flux, this peak will be reduced at the same time the starting torque is increased.

Methods of Reducing Field Inter-Action

The damping action of the shunt field in magnitude is proportional to the area traced by the curve of shunt current during its decrease, and this, in turn, is somewhat proportional to its lowest peak. There are three methods of reducing this area:

1. Altering the time constant of the shunt circuit.
2. Placing resistance in the series circuit.
3. Changing design constants.

A study of the curve of shunt current in Fig. 6 shows that the current decreases very rapidly and increases slowly. The increase is a function of the time constant of the circuit itself, but the decrease may be very rapid because the series current is changing at the same time but in the opposite direction and, therefore, the flux need not change rapidly. In fact, if L_1 and L_2 are zero in the fundamental equation, the current may reach its peak in zero time. Such phenomenon has been observed in case of very small leakage between the windings. If the time constant were increased, as by placing the field coils in parallel

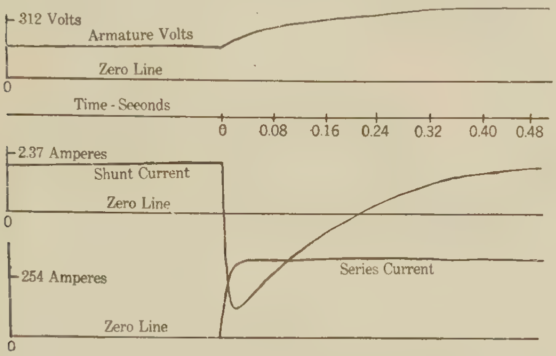

FIG. 10—CURRENT TRANSIENTS WITH SHUNT COILS IN PARALLEL

rather than in series, the shunt current would regain normal value more rapidly, thereby increasing the flux more rapidly. At the same time, however, the current peak is increased in a negative direction and the traced area will be larger than before.

If, on the contrary, inductance is added to the shunt field circuit, the negative peak is decreased and the area will be less. In Fig. 6, curves are plotted for the currents and flux, with a large inductance in the shunt circuit. These may be compared with the other curves in the same figure, in which L_2 was 10 henrys. It will be seen that the peak is reduced from 1.7 amperes to 0.5 ampere.

The oscillogram in Fig. 10 was taken with the field coils in parallel and may be compared with Fig. 2. It will be seen that the negative peak has been increased and the area increased even though the current regains steady state more rapidly.

Equation (VIII) in the Appendix, which is a simplification of equation (III) if the self-inductive coefficients are zero, states that the negative peak of shunt current depends directly on the resistance of the series circuit. Therefore, if the starting resistance is increased, the field interaction is decreased, and within limits, the starting torque will remain practically unchanged. In Fig. 11 it will be seen that the series current is less than in Fig. 2 because of additional resistance, and that the negative peak is somewhat reduced.

The design of the motor may be changed by altering the relative copper on the two fields. The worst condition is an equal division. Equation (8) also shows the interaction to be a function of the turns ratio, and that if more turns were placed on the shunt field and a smaller current were carried by the coils, transient conditions may be improved. It is not always feasible to make such changes, however, and in such cases another type of motor is the best solution. This, however, would rarely ever be necessary.

CONCLUSIONS

It is obvious from the preceding discussion that with many applications of compound motors, the action of the shunt field has no particular disadvantage. It is only in case the starting torque must be all that the motor could possibly supply, or in case the motor is constantly started and stopped, that such phenomena become important.

In case the shunt field current reverses appreciably and the flux rise is much slower than it would be, neglecting field interaction, (even though saturation is also taken into account in finding the flux rise in case there was no field interaction), it is probable that the application would be best fulfilled by a straight series or shunt motor. In the event that a compound motor is desirable for other reasons, however, the design may be altered by changing the relative amount of copper in the two fields.

In drawing general conclusions from the above, it must be remembered that there are many types of motors, so-called compound, including those which have only a small series or shunt stabilizing winding. Because field interaction is most severe with an equal division of copper in the two fields, this latter group of motors is only slightly affected by the described phenomena. In case of true compound motors, which derive a large portion of their flux from both fields, the

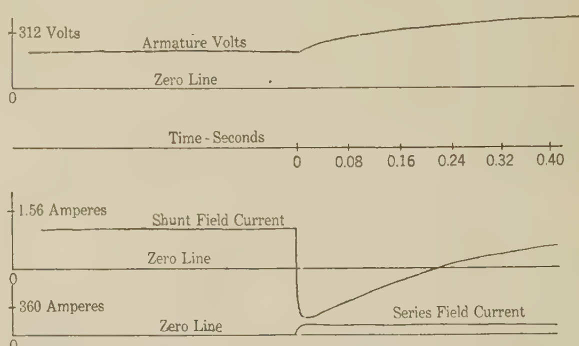

FIG. 11—CURRENT TRANSIENTS WITH INCREASED STARTING RESISTANCE

general conclusion is that on account of their peculiar transients, they must be applied with care.

Also, because of the variation in magnitude of starting resistance used with the motor, it is not possible to state definite conclusions with regard to a particular motor without taking into account the exact conditions of application. The contents of this paper may therefore serve to aid in checking doubtful applications and in making clearer the general phenomena of compound field interaction.

Abridgment of

Demand Metering Equipment

Its Application in Recent Developments

BY STANLEY STOKES[1] Member, A. I. E. E. and LESLIE V. NELSON[1] Non-member

Synopsis.—Public utilities which have to do with supplying electric power are continually finding themselves confronted by problems a little different from anything in the past.

New interconnections of superpower plants and transmission lines often present involved metering installations. The installation herein described has to do, generally, with such a condition and specifically has to provide for metering the simultaneous composite demand of an ultimate installation of 48 separate feeder circuits.

It is believed that this is the largest installation of its kind so far attempted. The importance of this particular job required a very exacting study of all factors and the operating results, to date, seem to bear out the solution. A novel scheme has been incorporated in the daily routine of handling the demand meter tapes. A general description of this is given. A few details of the physical installation are cited, which show the extreme care used through the whole installation.

While this application is specifically designed for metering, the principles involved are applicable to numerous other uses, some of which are mentioned.

* * * * *

THE expansion of modern superpower systems, through involved interconnections and remote points of metering, has created situationsrequiring special adaptations of existing apparatus and distinct development in many of its parts. It will be the purpose of this paper to treat in detail a specific metering problem which was encountered, giving a description of the apparatus selected and the reasons justifying this particular solution. It is felt that this solution is one which will apply to an increasing number of public utilities confronted with identical situations. At the same time it may be suggestive of others, for the apparatus has a wide use in problems dealing with time studies.

Certain electric power contracts were negotiated during 1927, whereby the entire output of the Cahokia Plant of the Union Electric Light & Power Co. of Illinois would be sold directly to three customers on a combined demand and energy basis. This required that each customer be metered for the maximum demand of his load in kilowatts and his total monthly consumption of kilowatt-hours. The maximum demand was defined as the integrated average load for that fifteen-minute interval in which the greatest total number of kilowatt-hours was taken. All three customers were to be metered in like manner.

The Union Electric Light & Power Co. is supplied entirely with its 60-cycle requirements from Cahokia by means of some 30 submarine cables crossing under the Mississippi River and terminating in distribution substations located at various load centers throughout the City of St. Louis. The ultimate development of Cahokia provides for 48 such cables, each radiating from the generator bus through its individual oil circuit breaker. The existing installation of 30 cables comprises three distinct capacities; *i. e.*, 3000-, 7500-, and 12,000-kv-a. per feeder.

This particular problem obviously becomes that of metering an ultimate of 48 individual circuits simultaneously, and of totalizing the demands of the different capacity cables in such a way that they will all have the correct effect upon the instruments.

The other two customers,—namely, the Illinois Power & Light Corporation and the Union Electric Light & Power Co. of Illinois,—are supplied by means of the new Cahokia transmitting substation which has been constructed to step up the energy from 13,800 to 69,000 volts. A portion of the load is transmitted four and a half miles over a common line, known as the Cahokia-Venice Transmission Line, to the Venice Substation, where the Venice Power Plant is tied in and used in times of emergency for relay service. Two lines emanating from this substation, one to Alton and the other to Stallings, supply a part of the load to these two customers. A third line extending directly from the Cahokia Substation to Belleville supplies the remainder of the load of the Illinois Power & Light Corporation. The general arrangement of circuits is shown in Fig. 1.

Another clause in the contracts specified that all energy be metered at the generating bus potential; that is, 13,800 volts. All meter readings consequently must be referred to a common voltage in order to properly assign transmitting and transformation losses to the individual. This necessitates high-voltage metering of the two customers' individual lines before they join in a single circuit. Both high- and low-voltage metering were installed at all points indicated on Fig. 1, without involving any special study. Readings from the high-voltage meters would provide the necessary ratios for dividing the readings of the low-voltage meters registering joint use.

No attempt was made to meter these two customers at one point, for it was recognized that this method would involve more unreliable elements than by diverse

1. Both of the Union Electric Light & Power Co., St. Louis, Mo.

Presented at the Regional Meeting of the A. I. E. E., St. Louis, Mo., March 7-9, 1928. Complete copies upon request.

metering and monthly calculations. This point was decided chiefly by local factors. Thus the second problem as to meter requirements was solved in a simple manner. It will be touched upon again under billing procedure.

A survey of the market for a solution of the problem of metering the 48 circuits of the Missouri Union Co. was somewhat disheartening. No simple solution was available, but a study of totalizing watt-hour meters was made. It was found that these were available in capacities up to and including eight circuits, but when applied to a 48-circuit problem, they became prohibitive in cost.

Further study indicated that a simple watt-hour

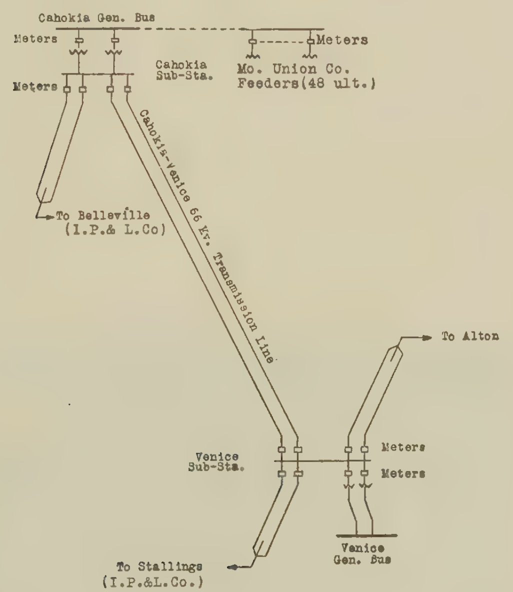

Fig. 1—Diagram of Customer Connections

meter equipped with a standard device for making contacts for the predetermined passage of a definite amount of energy would be the cheapest and yet most reliable solution, provided a means could be found of collecting these contacts from the watt-hour meters on the 48 circuits.

Two distinct methods seemed possible: the first scheme suggested that some means of collecting the contacts at definite regular intervals could be developed. In principle this would operate similar to an electric adding machine. The pressing of several keys would correspond to the making of contacts on several of the watt-hour meters. Periodically, the group would be totalized just as one presses a totalizing key on an adding machine. The time interval between collection of contacts would have to be less than that required for the making of two successive contacts on the watt-hour meter under greatest load. With this method, simplicity and low cost would obviously obtain. This principle had the disadvantage that if a contact on a watt-hour meter should "freeze" or stick, a contact would be transmitted to the printing demand meter at each collection interval. Thus, evaluating the contacts in terms of kilowatts would give an excessive demand reading and thereby penalize the customer. It was felt that any possible chance of error or trouble in the metering device which could be guarded against should be resolved in a manner favorable to the customer and thus preserve his good-will. This method, while it incorporated novel mechanical and electrical features, had a further limitation in its inability to register all impulses when there was a large number of watt-hour meters to be totalized. This principle incorporated a piece of equipment which would be required to operate continuously and be subject to appreciable wear. In view of these facts, it was found advisable to discard this method in favor of the second, which will be described at length.

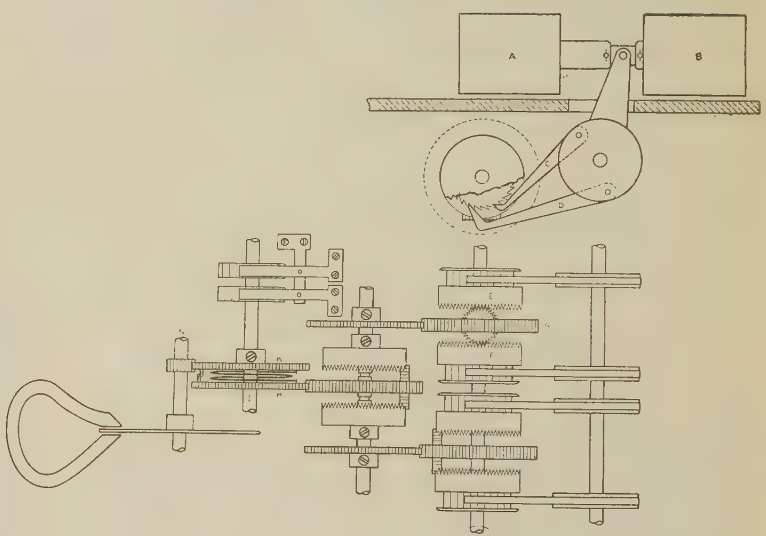

Fig. 2—Schematic Diagram of Four-Element Totalizing Relay

The second possible method provided that the contacts from the watt-hour meters be collected and recorded on a demand meter at the instant that they were made. With a multiplicity of meters,—48, for instance,—the probabilities were that frequently several contacts on separate meters would occur simultaneously. Some means of absorbing these contacts at the instant of making and of giving them out uniformly for registration was necessary of course so that none would be lost in the process. This principle involved no such limitations as were encountered in the first method. Any number of circuits might be totalized by simply pyramiding the recording instruments. It also had the advantage that the recording instruments were operating only at the time that watt-hour meter contacts were made. At times of no-load on the circuits, there would be no wear and tear on the recording instruments.

These fundamental considerations seemed to be provided in a totalizing relay on which the manufacturer agreed to make certain necessary modifications in his standard equipment to meet adequately our specifica-

tions. By means of the instruments shown and the schematic diagram of connections (Fig. 2), the general principle of operation may be followed. By passing an electric current through a watt-hour meter, the element is made to revolve, thereby driving the contact device which makes and breaks a circuit at intervals proportional to the loading of the watt-hour meter. A contact impulse eminating from a watt-hour meter must obviously be evaluated in terms of kilowatts before it leaves the meter. This is accomplished by making the gearing and number of cam teeth within the watt-hour meter proportional to the kilowatt constant of the meter itself. After a contact has been imparted to a totalizing relay, it loses its identity and value in relation

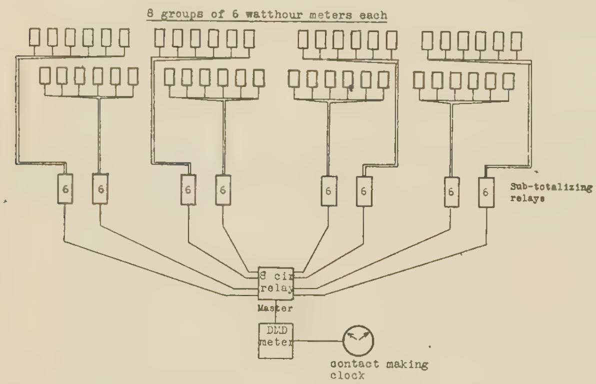

FIG. 3—SIMPLIFIED CIRCUIT LAYOUT FOR 48-CIRCUIT TOTALIZING DEMAND METER

to other contacts. Tracing this contact circuit, (Fig. 2), we find that a coil, A, is energized in a totalizing relay which actuates a rocker arm and, by means of a ratchet device, D, advances a shaft a definite number of degrees. Simultaneous contacts on two adjacent coils (not shown) are made effective through differential gearing, E and F. A contact is then transmitted through successive stages of gearing to a coil spring between gears H and K. This spring functions to store several contacts if they occur simultaneously, and by unwinding, revolves shafts I and N at a uniform rate, thereby giving out the same number of contacts as was received. The driven shafts are damped in their rotation by means of a disk and magnet. This final shaft, I, has two cams, L, and contact devices on it, so that its rotation is translated again into contacts which are recorded on a printing type of demand meter. Stops on the gears, H and K, on each side of the coil spring prevents over-registration of the relay. The use of double-contact devices instead of single is especially noteworthy. Each set of contacts is connected to two coils which work against each other. Once a contact is made and its coil energized, further successive contacts on this one circuit—such as is caused by chattering—have no effect until the other contact functions. This description covers the general operation of a single totalizing relay. By pryamiding these relays as shown in Fig. 3, practically any number of circuits or contacts may be recorded.

The 48-circuit installation comprises eight 6-circuit totalizing relays, which are designated as subtotalizers. The contacts on each subtotalizing relay are in turn connected to a coil on an 8-circuit totalizer, which has been designated the master totalizer. The impulses emanating from this master totalizer are recorded on a standard printometer. The 15-min. interval specified by contract for demand readings is obtained through clock-driven contacts which reset the printometer to zero reading every fifteen minutes.

Each 6-circuit totalizing relay has a contact ratio of five to one; *i. e.*, for every five impulses received, it gives out one to the 8-circuit master totalizer. The 8-circuit totalizer also has a contact ratio of five to one, giving only one contact to the recording printometer for every five received from the subtotalizers. As an example, assume that the printometer registers 150 contacts; this means that the 8-circuit relay has received 750 contacts in the 15-min. interval. On the average, each 6-circuit totalizer must have contributed 93.7 contacts and received 468.7 contacts from the 6-watt-hour meters connected to it. There being eight groups of watt-hour meters, a total of 3750 contacts must have been made in the watt-hour meters in the 15-min.

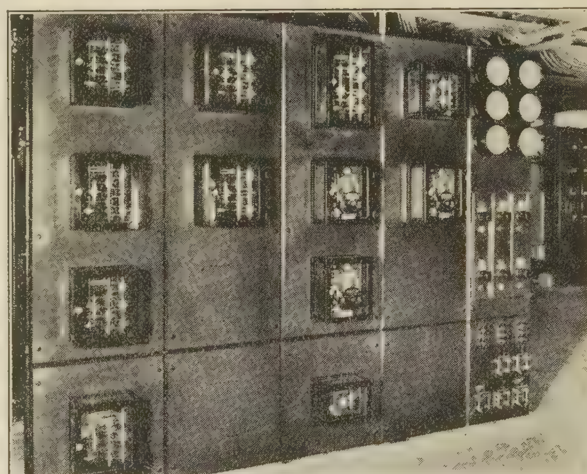

FIG. 4—FRONT VIEW OF 48-CIRCUIT (ULTIMATE) TOTALIZING DEMAND METER INSTALLATION,—CAHOKIA PLANT

interval. Each watt-hour meter, on the average, could have contributed 78.1 contacts per 15-min. interval, or 5.2 contacts per minute if all were evenly loaded and of the same capacity. With a permissible shaft speed on the watt-hour meter of 30 rev. per min. it would take slightly less than six revolutions of the watt-hour meter shaft to give one contact, or approximately one contact for each 12 sec. elapsed. This particular installation has a constant of 2000 kw. per contact as registered. With a maximum scheduled number of contacts of 150, this would indicate a customer demand of 300,000 kw.

It would be folly to expect perfect operation in this type of equipment in spite of the high standards of manufacture. In an attempt to guard against errors of registration, it was specified that each individual

totalizing relay should be equipped with a cyclometer so that the total number of impulses received by the totalizer from the group of watt-hour meters connected to it could be ascertained and checked periodically. The readings of the cyclometer dial when compared with the summation of the readings of the respective registers on the six watt-hour meters connected to it should check. Any failure of these figures to check very closely —*i. e.*, within a tenth of one per cent or thereabouts—would indicate a faulty contact mechanism on one of the six watt-hour meters. Periodic checking in this matter affords a simple means of locating and correcting any such troubles before they can become accumulative. The reading of the cyclometer dial on the master totalizer, over a period of a month, will also indicate the total kilowatt-hours supplied to the customer over the 48 circuits for the entire month. This saves considerable time at the end of the month when there is always a large amount of detail reading and checking. The daily checking of the cyclometers renders this figure accurate for use.

Because of their inherent points of design, meters and relays of this type are fundamentally foolproof. They do not require the manufacturing precision of a delicate watch mechanism or a high-grade clock. The laboratory methods used in checking, adjusting, and calibrating these instruments assure us of a high-grade solution of this particular problem. Such a metering installation, upon the readings of which millions of dollars are paid out annually, must be stable and reliable to justify the confidence of all concerned.

Fig. 4 shows the front view of the installed metering panels. The wiring on the back of the panels is continuous from the contacts in the watt-hour meter to the coil in the totalizing relay. No joints or splices have been tolerated and, therefore, it is expected that contact troubles which ordinarily occur in small current circuits will be eliminated.

Abridgment of

The Calculation of the Armature Reactance of Synchronous Machines

BY P. L. ALGER*

Member, A. I. E. E.

Synopsis.—*This paper presents new and simplified formulas for the armature leakage reactance of synchronous machines, and compares the results obtained with tests on 100 machines of varied types. The new formulas are characterized by novel expressions for the end leakage and for the "air-gap" or "differential leakage" reactances. Formulas for zero phase-sequence reactances also are given. The definitions of armature leakage and armature reaction reactances used are those proposed by Doherty and Nickle in 1926, and as a result, the leakage reactance has a much smaller value than has been assigned to it heretofore, thus requiring a rather fundamental revision of the ordinary conceptions of the flux densities existing in the various parts of a loaded synchronous machine.*

I. Introduction

The growing interest of operating engineers in machine reactances as system stability and short-circuit phenomena continually become more important together with the recent advances in the theory of synchronous machines, make renewed consideration of the subject of reactance calculation opportune at the present time. Papers on this subject have appeared in the JOURNAL'S pages at intervals over a period of more than 20 years, each paper marking a further refinement of methods and an advance in accuracy. At first, it was customary merely to estimate the numbers of leakage lines per ampere inch of embedded and free conductor, and multiply them by the respective lengths to obtain the reactance. Later, the reactance was segregated into several distinct elements that were calculated separately. These calculations have reached greater precision in connection with induction than with synchronous machines, due to their greater importance, and, in this case, the possibility of more accurate tests. Adams[11, 13, 14] first developed formulas for induction motor reactances, and later Fechheimer[9] and Doherty and Shirley[7] developed formulas for synchronous machines. In 1926 Doherty and Nickle[3] presented some fundamental extensions of the theory of synchronous machines, and proposed new and more precise definitions of armature leakage reactance and armature reaction reactance. The present paper adopts these new definitions and develops simple formulas for the accurate calculation of the two quantities for salient pole machines.

The reactance of armature reaction is here defined as the reactance due to the fundamental sine wave of air-gap flux produced by the armature current acting alone. It is calculated by means of the curves derived from flux plots by Wieseman.[2] There are two distinct values for it; the direct axis value occurring when the

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†For all references see Bibliography, complete paper.

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axis of armature m. m. f. coincides with the pole axis, and the quadrature axis value occurring when the axis of armature m. m. f. is midway of the interpolar space.

The armature leakage reactance is defined as the difference between the total or synchronous armature reactance and the above defined reactance of armature reaction. The distinction between the leakage and the armature reaction components of the total reactance is quite an arbitrary one, since no winding can have a definite value of leakage reactance except with respect to another winding. Some distinction of this character, however, is very desirable for convenience in calculating the transient reactance and for other purposes. The armature leakage reactance as above defined is as nearly equal as may be to that part of the total armature reactance which remains the same under transient as under steady conditions of operation.

Following Adams' treatment of the induction motor, the armature leakage reactance of a synchronous machine is divided into four parts; the slot, end, zigzag, and belt leakages. These four divisions of the reactance are commended here for the two reasons that they fit in very well with the new conceptions of leakage reactance, and that their adoption will tend to unify the theory of the two types of machine. Specifically, the total "air-gap leakage" due to harmonics of the air-gap flux is segregated into the two parts called zigzag and belt leakage, respectively, in order to permit the effects of the independent variables, number of slots, and number of phase belts to be separately taken into account.

All previously published formulas for zigzag leakage have involved the consideration of overlapping primary and secondary teeth, and so have taken into account inadequately the effects of flux fringing in the air-gap; thus they have been inapplicable to synchronous machines. Also, older formulas for end leakage have been frankly empirical in nearly all cases. The new formulas for these elements have been derived by considering the leakage flux to consist of revolving magnetic fields, divided into a fundamental and a series of harmonics. In each case, the coefficients of the resulting formula was derived from theoretical considerations alone, and no empirical multipliers were used to bring the results into agreement with practise, although simplifying assumptions were freely made, as the occasion demanded. Before going further, it is desirable to get clearly in the mind the distinctions between the four elements of the leakage specified. The end leakage reactance is due to the flux linking the end windings only. The slot leakage comprises all of the flux crossing the slots due to the armature current, but does not include flux passing from tooth to tooth in the air-gap space. There is evidently a slight error here because the flux lines near the mouth of the slot do not pass straight across, but bulge outwards into the gap. The zigzag leakage comprises all of the space harmonics of the air-gap flux, due to the armature current in a one slot per pole per phase winding which induces fundamental frequency voltages in the armature. This includes the flux which crosses from tooth to tooth in the air-gap and interpolar spaces without actually reaching the field surface, and so takes up the leakage flux at the point at which the slot leakage left it. The belt leakage then comprises all the remaining fundamental frequency voltage producing space harmonics of the air-gap flux due to armature current. This last reactance is the additional reactance that an actual winding has above that which it would have if there were as many phases as slots per pole. Thus, the zigzag leakage reactance is due to the deviation of the armature m. m. f. wave from a sinusoid caused by the limited number of slots, and the belt leakage reactance is due to the further deviation caused by the limited number of phases.

The belt and zigzag reactances together have been called[5] appropriately the "differential leakage," since they are due to the deviations of the armature m. m. f. from the ideal sine wave. They may also be called "air-gap leakage" since they represent the difference between the total and the armature reaction components of the fundamental frequency voltage producing air-gap flux. As the differential leakage reactance varies with the relative positions of the axes of the armature m. m. f. and the poles, the armature leakage reactance varies likewise, and has a slightly higher value in the quadrature than in the direct axis.[3]

Formerly, the air-gap flux due to the armature current was divided into two parts; that due to the armature reaction, and that due to "tooth tip leakage."[7] The armature reaction part was intended to represent the air-gap flux produced by the armature that links the field, but the determination of this flux was erroneously based on the linkages of the armature by the air-gap flux due to the field.[7] The remaining part of the total air-gap flux produced by the armature was then called tooth tip leakage. As the new definition of armature reaction includes most of this latter flux, we have abandoned the name "tooth tip" and called the small remaining part, the synchronous frequency voltage-producing harmonic fluxes, "differential leakage," as just described.

Bearing in mind these conceptions of the leakage reactances which we are going to calculate, the derivations of the formulas for them can be readily understood. In this abridged version of the paper, however, we shall omit all the work of derivation and proceed at once to the results of that work.

II. Armature Leakage Reactance Formula

Expressed as a fractional voltage drop due to full-load current (per unit value), the armature leakage reactance of a polyphase salient pole synchronous machine with a barrel-type armature winding and fractional slots per pole, in inch units, is

$$X_l = \frac{20\,A}{K_p^2\,K_d^2\,\phi}\left[\frac{P}{S}\frac{L}{}\left(\frac{3\,p+1}{4}\right)\left(\frac{d_3}{w}+\frac{d_1}{3\,w}\right)\right.$$

$$\left.+\frac{0.3\,(3\,p-1)\,D}{P}\right]+\frac{1.1\,A}{F}\left((P/S)^2+0.6\,K_B\right) \quad \textbf{(37)}$$

If integral slots per pole are used, the $(P/S)^2$ term should be multiplied by 0.5. If in addition, the machine has a squirrel-cage winding, the K_B term is to be omitted. The reactance is assumed to be the same in both axes, but actually it is greater by about ¼ of the A/F term in the quadrature axis than in the direct axis.

In formula (**37**), the first term in the brackets represents the slot leakage. It is not exact, but is very nearly so for normal three-phase machines with a winding pitch, p, between 2/3 and 1, and is commercially accurate for two-phase and three-phase machines with

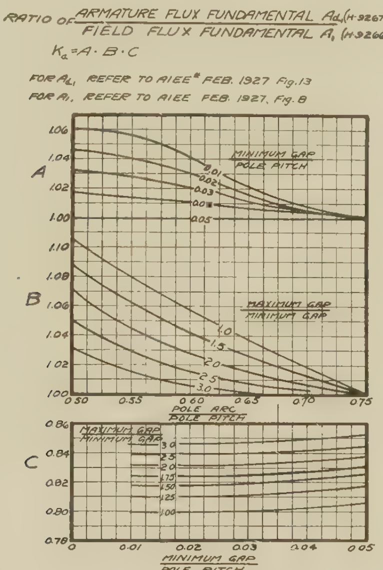

FIG. 7

pitches between 0.5 and 1. If the pitch is greater than 1, $2 - p$ is to be substituted for p in the formula. The complete formula is given in the original paper. The second term in the brackets represents the end leakage. It was derived by combining more complicated expressions for the two parts of the end leakage flux, the "axial flux" and the "peripheral flux." The resulting expression is reasonably accurate for winding pitches between ½ and 1¼, but is obviously in error for pitches much below 0.5. The first (A/F) term represents the "zigzag leakage" due to the slots, and the second represents the "belt leakage" due to the phase belts of a regular winding. In deriving these expressions, the additional belt leakage due to the fractional m. m. f. harmonics of an irregular winding was assumed to be just equal to the zigzag leakage for that number of slots, approximately in accordance with the results of calculations for some actual windings. As the K_B term in (**37**) is generally very small in comparison with the other terms, it is usually neglected.

As the value of X_1 found from test is totally different depending upon how the armature reaction is converted into equivalent field ampere-turns, it is necessary to consider the matter before proceeding to a comparison of test reactances with those given by (**37**).

Wieseman[2] has derived accurate coefficients by flux plotting for the calculation of the fundamental sine wave of flux produced in a salient pole machine by the concentrated field turns, and by a sinusoidally distributed armature reaction. By taking the ratio of these two coefficients, the necessary factor, K_a, to convert the armature reaction ampere-turns into equivalent field ampere-turns can be derived. This has been done by Mr. Wieseman, and the result is shown in Fig. 7. By substituting the quadrature axis coefficients, (also given in reference No. 2), for those of the direct axis, the armature reaction and the total or synchronous reactance in either axis can be accurately calculated.

The usual way to determine the armature leakage reactance by test is first to take open- and short-circuit characteristic curves which give armature voltage on open-circuit and armature current on sustained short-circuit, respectively, as functions of field current. Then the field current, corresponding to full-load armature current on short circuit, divided by the field current corresponding to normal voltage on the air-gap line, is equal to the synchronous reactance expressed as a fraction. By subtracting the calculated armature reaction, also expressed as a fraction of the no-load air-gap field ampere-turns, (from the test value of synchronous reactance), the test value of armature leakage reactance is found. The calculated armature reaction ampere-turns are given by (**10**), multiplied by the value of K_a from Fig. 7.

As the errors of the test value of synchronous reactance probably average one per cent, and as Fig. 7 also involves slight errors, it is evident that this method of obtaining the leakage reactance is inherently very inaccurate. On high-speed machines, the leakage reactance is very small by comparison with the total reactance, so that in this case, the results are particularly inaccurate. Nevertheless, as explained in the complete paper, other methods that have been proposed for measuring the leakage reactance involve worse defects, and so the usual method just described has been followed in checking the new reactance calculations against test results.

III. COMPARISON OF TEST AND CALCULATED RESULTS

In Tables III to VII inclusive, the calculated and test values of synchronous reactance are compared for five groups of machines of different types. The machines were selected at random, and the tests were all made in the regular commercial routine. The average absolute error for the entire list of 100 machines

is 0.4 per cent, and the average numerical error is 1.7 per cent, so that the results are as accurate as could reasonably be expected when the errors of test and those inherent in Fig. 7 are considered. If the value of the armature reaction reactance, X_{ad}, and the test value of total reactance, X_d, are assumed to be exact, the test value of leakage reactance can be found by subtracting one from the other. This has been done for each group of machines, and the average errors between the test and calculated values of X_l for each case are given in Table VIII, together with the corresponding errors in X_d.

On this basis the average absolute error of the leak-

TABLE VIII

Type of machine	Test / Calc.	Per cent Absolute error	Per cent Numerical error: From 1	Per cent Numerical error: From mean
	Errors in values of X_l			
High-speed (II)	0.86	−13.6	31	30
Medium high-speed (III)	1.01	1.0	11	11
Medium low-speed (IV)	1.06	6.3	11	10
Low-speed (V)	1.06	5.7	12	10
Small low-speed (VI)	1.04	3.6	8	7
	Errors in values of X_d			
High-speed (II)	0.992	− 0.8	1.9	1.7
Medium high-speed (III)	1.000	0.0	1.0	1.0
Medium low-speed (IV)	1.008	0.8	1.4	1.3
Low-speed (V)	1.011	1.1	2.2	1.8
Small low-speed (VI)	1.019	1.0	1.9	1.7

age reactance for the 100 machines is 0.6 per cent, and the average numerical error is 14.6 per cent. The worst errors occur for the high-speed machines, and inspection of Table VIII indicates that the calculated value of X_p is appreciably too high for high-speed machines and a little too low for low-speed machines. By empirical adjustments of the coefficients of the end and differential leakage components of the reactance, it is evident that these errors could be reduced. Such adjustments of the constants, however, should be made by each manufacturer for himself, as they will depend upon the particular end winding constructions and so forth that each one uses. The formulas as given were derived straightforwardly from theoretical considerations, and no attempt has been made to make empirical corrections, although simplifying assumptions have been freely used.

The causes for the varying magnitudes of error shown in Table VIII are brought out more clearly by a study of the relative proportions of the various elements of the total reactance for the different types of machines. Table IX gives the average ratios of slot, end, and differential leakage to the total leakage reactance; and also the average ratio of the total leakage reactance to the armature reaction reactance for each case. Since in the high-speed machines, X_l averages only 6 per cent of X_d, while in the small low-speed machines it averages 25 per cent, it is clear that a given error in the measurement of X_l makes more than four times as great an apparent error in X_l in the former as in the latter case.

TABLE IX

Type of machine	Average ratios: X_{Slot}/X_l	X_{End}/X_l	$X_{Dif.}/X_l$	X_l/X_d	X_l new / X_l old
High-speed	0.37	0.60	0.03	0.059	0.56
Medium high-speed	0.57	0.35	0.08	0.087	0.58
Medium low-speed	0.60	0.32	0.08	0.132	0.66
Low-speed	0.67	0.16	0.17	0.189	0.70
Small low-speed	0.58	0.16	0.26	0.252	0.72

This partially accounts for the relatively large numerical errors in X_l for high-speed machines.

The last column of Table IX gives the average ratio of the new value of leakage reactance to the value given by the older formulas derived by Doherty and Shirley.[7] This ratio varies from a little over one-half for the high speed, to nearly three-quarters for the low-speed machines. The percentage of error between test and calculated values of X_l is thus magnified on the new basis, so that a direct comparison of the accuracy given by the two formulas cannot be made. The older formula had an average apparent error of about 16 per cent, so that taking into account the test errors, which cause a considerable part of the dispersion, the new formula is indicated to have about half the true error of the old.

IV. Zero-Phase Sequence Reactance Calculations

The zero-phase reactance is important in the calculation of single-phase short circuits, circulating currents in delta windings and in other cases. The zero-phase sequence currents are in time phase in all the armature windings, and therefore they produce no fundamental m. m. f. Therefore the end leakage reactance can be neglected, and only the slot leakage and the differential leakage elements of the reactance need be considered. The resulting formula for the zero-phase reactance of a three-phase, 60-deg. belt winding, with a winding pitch between $^2/_3$ and unity, expressed as a fraction, is

$$X_{\text{zero phase}} = \frac{20\,A}{K_p^2\,K_d^2\,\phi}\left(\frac{P\,L}{w\,S}\right)$$

$$\left[(3\,p-2)\,(d_3) + (9\,p-5)\,\frac{d_1}{12} - (9\,p-8)\,\frac{d_2}{12}\right]$$

$$+\frac{4\,A\,K_0\,(p-2/3)}{F\,K_p^2\,K_d^2}$$

$$\left[\left(\frac{P}{S}\right)^2 + \frac{1}{27} + 7/18\,(p-2/3) - (p-2/3)^2\right] \tag{38}$$

The coefficient K_0 is introduced in (38) to allow for the reduction of the harmonic fluxes, especially the third, by induced currents in the rotor circuits. As all the terms except the first in the last brackets of these equations represent third harmonic fluxes, these

terms are generally reduced to a fraction of their apparent values, and K_0 should ordinarily be taken as less than 0.5.

The zero-phase reactance has been calculated for two machines, and the values compared with tests, with the following results:

Poles	Kv-a.	Freq.	Winding pitch	Assumed value of K_0	Zero-phase Sequence Reactance Calcu-lated	Test	Per cent error
6	435	60	2/3		0.026	0.021	−24
36	20,000	60	0.80	0.25	0.070	0.0675	4

V. Conclusions

It is believed that equation (**37**) is at once the most accurate and the simplest comprehensive formula that has been published for the armature leakage reactance of a synchronous machine. It requires no curves, no logarithms, and no tables for its use,—only a few slide rule operations,—and it gives a value of leakage reactance which, added to the armature reaction reactance derived from flux plots, quite accurately checks the test values of synchronous reactance for the entire range of salient pole synchronous machines in commercial use.

The leakage reactance so determined averages about two-thirds of that given by the widely used formulas derived in reference No. 7, since the latter included as leakage reactance a part of the fundamental sine wave of air-gap flux due to the armature, which links the field winding in the direct axis, and thus constitutes a part of the true armature reaction. The new value of leakage reactance, added to the squirrel-cage reactance, checks observed standstill reactances of synchronous motors; and, added to the field reactance, checks the values of transient reactance found from oscillographic tests on synchronous generators. With the old reactance formulas, rather arbitrary reductions of the calculated field reactance and tooth tip reactance were necessary before checks with transient and standstill reactances could be secured. Finally, with the old formulas, the calculated increase in internal voltage of a synchronous generator under load gave much higher flux densities in low-power-factor machines than actually occur; so that arbitrarily reduced values of field leakage under load were used in calculating saturation curves, thus establishing a series of compensating errors.

There is no space to demonstrate the validity of these statements here, and they are simply made to show that the acceptance of the new values of leakage reactance involves a fundamental revision of the generally adopted design constants of synchronous machines. In writing the paper, an effort has been made to make the new formulas and the new definitions such that the further refinements which the future will bring can be added without again altering our conceptions or the orders of magnitude of the characteristic constants of design.

Acknowledgments

The writer wishes to express his appreciation of the helpful advice he has received from Messrs. R. E. Doherty and R. H. Park, in the preparation of this paper.

Nomenclature

A = Maximum ampere-turns per pole of armature reaction

d_1, d_2, d_3, w = Slot dimensions shown in Fig. 1 of complete paper

D = Gap diameter

F = No-load air-gap field ampere-turns per pole

K_B = Belt leakage constant, given in Fig. 6

K_p, K_d = Pitch and distribution factors of armature winding (less than unity)

L = Gross core length

p = Winding pitch expressed as a decimal

P = Number of poles

S = Total number of slots

X_d = Total, or synchronous, reactance in direct axis

X_l = Total armature leakage reactance

ϕ = Flux per pole in c. g. s. lines.

SPECIAL ALLOY ELIMINATES EROSION OF IMPULSE-WHEEL NOZZLES

Erosion of impulse waterwheel nozzles, always a problem in high-head plants, seems to have been successfully met by the San Joaquin Light & Power Corporation, Fresno, Calif., by the use of "Stellite," a very hard and tough alloy. At the company's recently completed Balch high-head plant bronze or cast-steel nozzles had a life of from 35 to 40 days only, due to the cutting action of the water.

Although the water is very clean and free from abrasive material it was found that the water passing through the 7⅛-in. nozzles with a velocity of 360 ft. per second under an effective head of 2243 ft. had a very decided erosive action on the throat rings and nozzles of the 40,000-hp. double overhung waterwheel. By welding "Stellite" onto cast-steel nozzles no signs of erosion are evident on the main waterwheel nozzles after two months and on the exciter wheel nozzles after six months of operation. The alloy comes in ¼-in rods and is welded onto the steel nozzles with an acetylene torch, after which the nozzles are put into a lathe and ground down with an emergy wheel, since the metal is so hard and tough that it cannot be worked with a lathe tool. The work is done by the power company's men on the job at a cost of approximately $75 per nozzle.—*Electrical World.*

Steam will be generated at 1350 lb. per square inch pressure in the new Deepwater (N. J.) station, owned jointly by the American Gas & Electric Company and the United Gas Improvement Company.

Transatlantic Telephony

Service and Operating Features

BY K. W. WATERSON[1]

Fellow, A. I. E. E.

THE introduction of telephone communication between Great Britain and the United States required the fitting together of the practises of two telephone organizations. The development of usage between subscribers in the two countries involves questions of different telephone habits and experience. It may help to define the problem of setting up a service of this kind if at the start I mention one or two of the most important characteristics of long distance service in the two countries which illustrate outstanding points of difference.

In Great Britain, only number service is available; that is, a service under which the telephone administration undertakes merely to obtain a connection with a specified telephone and on which the message toll charge is assessed in all cases, where an answer is obtained from the telephone called whether or not the person desired is there. In the United States, this same number service is available at about the same initial rates as in England. In addition, we have a so-called person-to-person service on which, for a charge approximately 25 per cent above that for number service at the longer hauls, we undertake to obtain connection with a particular person who is specified in the order for service. In case of inability to reach the particular person desired, the full message charge is not assessed, but a so-called report charge is made which is about 25 per cent of the station charge, tapering off in percentage to a maximum charge of one dollar. This difference in the class of service available in the two countries is a matter of importance because of the fact that our experience here in America shows that on the longer hauls and at the higher rates, about 85 per cent of the calls are on a person basis, whereas at short hauls, the large majority of calls are for a number only.

In both countries, the toll rates provide for an initial talking period of three minutes. In Great Britain, additional use of the line is charged for on the basis of three-minute units and for each, the charge is the same as the initial rate. In the United States, additional use is charged for on a one-minute basis—each minute's charge being about one-third of the initial—a finer measure of actual use and one which, makes long distance telephoning considerably less expensive particularly at the higher rates.

In the United States, the general practise is to allow subscribers to talk as long as they wish except on rare occasions due to emergencies, such as storm breaks. In Great Britain, subscribers are notified at the end of three minutes and are limited to a maximum use of six minutes if other calls are waiting. This difference in the allowable length of long distance telephone conversations has developed out of basic differences in toll service as regards the provision of plant and the resultant speed of service. In the United States, we plan to give a very rapid service and we provide toll line plant to meet these needs. This policy seems to best meet the needs and desires of American users and to have been a large factor in the rapid development of our toll business. As a result, practically all toll and long distance calls are placed at the time when the connection is wanted and subscribers are often impatient if their calls are not completed immediately. In Great Britain, the plan has been to maintain as high efficiency as practicable in toll line plant and this naturally results in a somewhat slower long distance service. British subscribers are accustomed to longer delays than ours in obtaining connections. There is considerable advance booking. Under this condition, the limitation of the talking period, which I have already mentioned, is a practicable means of making the service available to as many users as possible and also of avoiding possible cases of unfair use of the lines by certain individuals to the exclusion of others. This difference in practise regarding the allowable length of conversation is a matter of particular moment in connection with a service like the transatlantic service, for the reason that our experience has shown a definite tendency for users to talk for longer periods on the long haul, higher-rate business. This is probably indicative of the greater importance or different nature of this class of telephone communication. Whatever the reason, calls at 250 mi. average under five min., at 500 mi. 5½ min., at 1000 mi. six min., and transcontinental calls, 6½ min.

In Great Britain, distances are relatively short. London-Glasgow, for example, represents one of the important longer haul routes, and the air-line distance is about 350 mi. On international calls, London to Berlin is one of the longer hauls at which service is available, and this is under 600 mi. In Great Britain, there is relatively small development of telephone usage at these distances. In the United States, on the other hand, we have transcontinental service over some 3000 mi. with considerable business at this and other long distances. Our connection with the Cuban Telephone Company has also given us experience with very long haul service. So, in the matter of special long distance problems and in the development of long distance

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telephone usage, the experience has been largely on this side of the water.

The service arrangements for this transatlantic undertaking were made through discussions carried on in London by representatives of our organization and officials of the British Post Office. While there were a good many problems to be worked out, there was the usual result when both parties desire to cooperate and to discover the best solution,—an agreement was soon reached. It was decided that the service needs of transatlantic telephony would best be met by a single class of service with one rate covering either number or particular person usage. Experience in the Bell System had indicated that on long haul business of this nature, practically all calls would be for a designated person and this has been borne out in the transatlantic usage. The rate between Great Britain and twelve states in the northeastern part of our country was fixed at \$75 for three min., with an additional minute charge of \$25. A report charge, of which I have already spoken, was fixed at \$10 for use in certain cases where particular persons called could not be reached. The British Post Office preferred to apply the same rate to England, Wales, and Scotland. Because of its wide expanse and expensive land line plant, the United States was divided into five zones for fixing additional land line charges over and above the New York terminal rate. These rate zone lines follow state lines. The zone rates go up in \$3 steps as we draw away from New York. Zone rates follow reasonably well the land line charges for service from New York. This zoning plan was adopted to simplify the means of quoting and computing the transatlantic rates abroad as compared with superimposing the more finely measured land line rates on the New York terminal charge.

For communications extending beyond the initial three-min. period, the plan of charging on a single-minute basis was adopted, as it seemed the most equitable; particularly in view of the distances and charges involved.

In setting up service and operating arrangements, it was necessary to give consideration to different conditions which would exist dependent upon the volume of business to be handled over the transatlantic channel. We had to consider operating practises which could be used satisfactorily either under conditions of high load and possibly delayed service, or of light load and fast service. As a means of insuring service to as many users as possible in periods of heavy business, agreement was reached that there should be a 12-min. limit on individual usage in case other calls were awaiting assignment to the radio channel. So far, there has been no occasion to enforce this limitation. The limitation of 12 min. was adopted instead of the usual 6-min. limitation common in British telephone practise, for the reason that due to the relatively long talk periods on business of this kind, the 6-min. limitation would have resulted in interfering with too large a proportion of these communications.

One problem of interest involved in the transatlantic service was that of fixing rates which allowed of satisfactory expression either in terms of English pounds and shillings or in American dollars. For this purpose, four shillings were considered the equivalent of an American dollar. The rate from London to New York, for example, is 15£ for three min. and 5£ for each additional minute. Our zone rate steps of \$3 for the initial period and \$1 for each additional minute were so set in order to allow of even dollar and even shilling quotations for the zone charges. For example, the rate from Cleveland, (which is in our second zone), to London, is \$78 for 3 min. and \$26 for each additional minute. The same rate quoted from London is 15£ 12s. for three min. and 5£ 4s. for each additional minute. Rate treatment of this kind was thought desirable, not only to allow of easy expression of rates in either English or American money, but also to avoid odd cents in our service charges.

Another problem had to do with the fixing of the hours of service so that the service would be most valuable and usable, with due regard to the five hours difference in time between New York and London. At the time the service was opened, limitations on the use of the Rugby sending station for telephone transmission made it possible to keep the channel open only 4½ hours during the day. The hours from 8:30 a. m. to 1:00 p. m., New York time, which correspond with 1:30 to 6 o'clock, London time, were adopted as allowing the maximum overlapping of the London and New York business day. Later, it became possible to extend the hours of operation so that now the service is available 10½ hours—7:30 a. m. to 6 p. m., New York time, which is 12:30 to 11 p. m., London time. The fact that both London and New York are on a daylight saving schedule in the summer months has required some shifting of the hours of service as these time rearrangements are effected on the two sides of the water.

The operating arrangements set up for the handling of this business provide traffic control operation at the New York and London long distance offices. These offices have direct access to the radio channel via the radio stations at Rocky Point and Houlton and at Rugby and Cupar where technical operators have the transatlantic channel under constant supervision and control. The New York and London long distance offices have special equipment arrangements necessary for connecting the radio channel and the land lines. On calls terminal at New York or London, the operation is similar to that on other terminal calls. On calls involving points beyond New York and London, the New York and London operators assume control, holding the land lines in readiness for prompt connection to the transatlantic channel, supervising the connection and fixing the amount of chargeable time, special measures being provided to protect the user from overcharges that might result from conversations being longer than otherwise necessary because of static

and other atmospheric disturbances. The operating method is set up to require a minimum of time on the transatlantic channel for passing calls back and forth and preparing connections.

The personnel necessary to operate the transatlantic circuit is probably not generally appreciated. While two operators in London and two in New York can readily handle the calls themselves, there are six stations, three in each country, for operating and controlling the radio channel and from 35 to 40 men are needed for this work. This force could, of course, handle much more business than is now offered.

Just as the experience with special long distance operating problems and with the development of long distance usage had been largely on this side of the water, so in the matter of international telephone arrangements the experience had been largely with the British Post Office. We have had connection with Canada for many years, but in none of our interchange of business with Canadian companies have we encountered the problems incident to European international communication. On the other hand, the British Post Office has communication with many countries on the continent and has played its part in the various European conventions and conferences looking to the betterment ofi nternational telephone agreements and communication in Europe. So their experience was particularly helpful in shaping up the contract arrangements. In general, the contract between the British Post Office and the American Telephone and Telegraph Company covers such matters as responsibilities of the two administrations, classes of service, rates, broader operating provisions and settlement matters.

Turning now to the question of the results which are being obtained in this transatlantic service. During the first year, something over 2300 connections were established. This is an average of about seven a day, if we include Saturdays, Sundays, and holidays, on which days as a general rule the flow of telephone traffic is relatively low. Usage is not very different east and west, something like 55 per cent. of the business having originated on this side. Some business from the other side is, of course, from traveling Americans. After the first two months, January and February, when the business amounted to about 250 messages a month and was affected largely by formal openings and curiosity calls, the traffic fell off, and during the summer it was not more than half as great as it had been in the first two months. This may have been due partly to falling off in business activities and possibly also partly to the fact that more atmospheric difficulties are experienced during the summer and the service is then somewhat less dependable. As a matter of fact, there was less atmospheric difficulty than we had anticipated. Starting with September, the business has shown a steady increase. On Christmas Day there were 44 messages.

About half of the transatlantic calls are between New York and London. Over 70 per cent of them originate or terminate in New York City and the remaining calls involve points scattered over the rest of the country. Considering the type of usage of this transatlantic service, nearly half of the calls appear to be of a social nature. As to calls for business purposes, banks and brokerage concerns account for the greatest use so far.

In general, the quality of speech transmission has been more satisfactory than the preliminary tests indicated it would be possible to maintain throughout the year. The radio link is, of course, under careful observation throughout the service period and is not assigned for commercial use unless it appears that reasonably good communication will be obtained. Except for two summer months when atmospheric conditions made telephone communication impossible on an average of about two hours a day, the lost time due to static and other such troubles in the radio channel has been relatively small.

Except for brief periods on individual days, the traffic volume has not been sufficiently high to result in any problem in providing a fairly prompt service. At times, and particularly during the summer months, individual calls have been delayed due to the fact that at the time they were offered, atmospheric conditions made it impossible to use the transatlantic channel. As the business develops, it will doubtless be necessary to adopt special measures for evening, the flow of business throughout the period that the transatlantic channel is open for service. At such time as traffic develops to a point where some artificial leveling of the load is required, we would expect this service to involve advance bookings and longer delays than we are accustomed to here in the United States in our internal services. Pending the availability of other transatlantic channels through the use of short wave lengths or otherwise, I do not believe that this type of service would necessarily be seriously objectionable or deterrent to business development. As a matter of fact, a good many calls are not filed in advance.

Difference in the English language as spoken in London and New York became evident as soon as our New York operators were placed in communication with the operators in London. Each group expressed some concern as to what the other was doing to their language. I believe the London operators were inclined to think the broken English spoken by the telephone operators in Holland was sometimes easier to understand than New York City English.

The self-confidence of Americans evidenced itself in the considerable number of calls filed for the nobility, cabinet ministers and other men in the public eye. The fact that most of these calls were accepted by the persons called indicated their willingness to play the game. Other evidences of this same confident attitude were the suggestions from individuals that they be given a free call so that we could capitalize on the publicity that they would put into their advertising. Others advised us after using the service that, for a

consideration, they would allow their names to be used in our publicity material.

I have spoken of some of the operating problems in setting up the transatlantic service and of our experience in handling this service since its inauguration about a year ago. The operating and service arrangements have worked out satisfactorily. The service as a whole has been considerably better than we had anticipated. The volume of business is small but the business now being handled is in line with our general experience in the development of long distance usage. In a situation of this kind, full consideration should be given to the fact that, generally speaking, potential traffic volumes decrease with distance. Telephone service like the transatlantic is a new means of communication. It will not only take time for potential users to become convinced that satisfactory communication can be carried on by telephone but time is required before they will break away from dependence on other means of communication such as the cables and mails with which they have had long experience and which may have appeared to meet their needs.

The development of our transcontinental business is of interest as this route may be considered as close a parallel as we can find to the transatlantic situation. For several years after the opening of the transcontinental service, the business was small but it has since greatly increased.

The transatlantic channel is a radio channel and this suggests a possible lack of privacy such as is obtained in ordinary telephone communication. Actually, the chances for conversations being picked up by persons to whom they would be of interest or value are rather remote, but this possibility has doubtless had some deterrent effect on the development of business. It is expected that these deterrent factors will be removed in the near future through the introduction of new equipment arrangements which will assure a high degree of privacy on these overseas conversations.

Possibilities for growth must be present in a communication system at the terminals of which we have New York and London, the largest business centers in the world, both English speaking. On this side, the service has already been extended beyond the United States to Canada and Cuba, and will be extended to Mexico. On the other side the service has recently been extended beyond England, Wales, and Scotland to important cities in Belgium, Holland, Germany and Sweden. Further extensions are under consideration to other important continental cities between which and this country there is undoubtedly potential business. As the service is extended beyond Great Britain, a language problem appears. So far, about 5 per cent of the conversations are not in English. For the time being, we are relying upon the London operators for smoothing out language difficulties in establishing connections and the problem is, of course, not a new one to them. We are planning, however, to set up an operating force here in New York which can communicate in their own language with users who are not speaking in English.

Not only from a technical viewpoint but in other respects we are gratified at the results of the first year's operation of the transatlantic service and we look forward with confidence that this service will be, not only the quickest, but an essential factor in communication between the old world and the new.

HIGH-PRESSURE STEAM WINNING MANY VICTORIES

Plenty of expectation has been current that operating troubles would increase faster than a straight-line ratio using steam above 400-lb. pressure and 700 deg. total temperature. Through the eyes of ultra conservatives apparatus for these heavy duties has been regarded skeptically in not a few installations. However, evidence has been growing that the art has been permanently advanced by raising pressures and temperatures, although the industry is still too much in the dark as to the economic justification of these new developments.

George A. Orrok gave the recent Midwest Power Conference at Chicago a valuable paper upon operating experience with high-pressure and high-temperature steam, and his conclusions that there now appear to be no serious difficulties up to at least 2000 lb. are indeed significant with respect to the solution of the important physical and metallurgical problems concerned. Reports from a representative number of high-pressure installations declare that most of the anticipated troubles with equipment have been absent and that operating difficulties are on the whole no greater than with the ordinary 200-lb. stations. Most of the troubles reported pertain to minor though essential equipment, like gage glasses, fittings, glands, gaskets, and so forth, and have been well taken in hand. The boilermakers state their readiness to guarantee service up to 900 deg. fahr. when specified, and alloy steels for tubes, shells and castings are now available for more difficult operating conditions than have prevailed in the past. Operators report both thermal and commercial economy in the use of higher pressure, and this is borne out by repeat orders for similar apparatus, probably the best of all indications of success.

The favorable results which have been coming to light in regard to the operation of high-pressure and high-temperature plants should be supplemented in the near future by the release of more over-all cost data and analyses. When these become more generally available, engineers will be in a still better position to determine the most economical pressure and temperature to use in a particular case. Unless the economic factors in plant experience are liberally exposed to the analytical fire of the profession, progress will be slower than the splendid achievements of physical and chemical engineering in this field deserve.—*Electrical World.*

Abridgment of

Arc-Welded Structures and Bridges

BY A. M. CANDY[1]

Member, A. I. E. E.

Synopsis.—The use of arc welding for constructing buildings, machinery, bridges, etc., has come into prominence during the past eighteen months, due to the merits of the process becoming recognized by a number of designers. Undoubtedly within the next few years the applications of the process will be extended rapidly as our available data are corroborated and amplified and as the limitations of the process become well defined.

The arc welding process of joining steel members to produce a fabricated structure, either to replace riveting or to take the place of castings, will produce results not obtainable in any other way known at present. Among the advantages of arc welding are the following:

1. The weight of materials required in a member or structure can be reduced by as much as 18 per cent.

2. No material is removed from members for welded connections such as rivet holes for riveted construction.

3. The weight of connecting material in some cases can be reduced 50 per cent to 90 per cent.

4. Absolute fixation of one member to another can be easily and economically obtained.

5. Continuity of members intersecting others can be readily obtained.

6. Greater rigidity can be obtained in a structure.

7. Overlapping members can be completely sealed by weld metal, thereby excluding moisture, preventing corrosion, and making a structure easier to paint.

8. Changes in or additions to structures can be made with a great saving in both time and expense.

9. More pleasing designs and in some cases, designs impossible by other processes, can be produced.

10. The welding process is practically noiseless.

* * * * *

In the past when beams or columns were required of section greater than the largest commercial rolled shapes available, they were constructed of angles for flanges and stiffeners and a plate for a web as shown in Fig. 1. Today, by using the arc weld process, a similar beam can be made from plate material exclusively (See Fig. 2). The former girder weighs 798 lb., and carried a maximum central load of 68,900 lb. The latter weighed 18 per cent less, or 656 lb., and carried a maximum load 13 per cent greater, or 78,000 lb. The load deflection diagrams of these two girders are shown by Fig. 3, as 20 and 20-A, for riveted construction using angles and plates whereas 21 and 21-A are designed for welding using plate material only. This latter design was used for the large second floor girders in the Sharon arc welded building (Fig. 4). These occurred in pairs over the crane runway illustrated in Fig. 5. These girders weighed 9 tone each, whereas girders made of angles for flanges and stiffeners for riveted design had an estimated weight of 11 tons which shows 18 per cent saving. Since there are 22 of these girders in the building, a total of 44 tons of steel is saved by the welded design.

For the first arc welded girder type railroad bridge, this same construction is used for the main side girders, each weighing 6 tons, (Fig. 6). This bridge has a span of 53 ft. 9 in. and is 62 ft. 4 in. long over all, requiring 20 tons of steel.

One of the advantages observed in the design and construction of this bridge was the ease of connecting the inside sketch stiffeners to the main girder webs and top faces of the floor beams as compared with the connection details which would be required for riveted construction.

The weight of connecting material for welded joints is very much less than for equivalent riveted connections. For example, the 9-in. *I*-beam, (Fig. 7), required only two pounds of weld metal to attach it to the columns and it withstood a maximum central load of 67,200 lb. In the case of the specimen, Fig. 8, the connecting angles and rivets weighed 22 lb. and the specimen carried only a central load of 58,700 lb. or 12½ per cent less capacity with 11 times the weight of connecting material.

The load deflection diagrams of these specimens are shown by Fig. 9 curves No. 8 and No. 9, respectively.

These same specimens illustrate the fact that complete fixation of the 9-in. *I*-beam to the column was obtained in case of the welded specimen as all failure was due to buckling of the beam top flange and crippling of the web. In the case of the riveted specimen the first failure was the bending of the top angles followed by flange buckling and web crippling.

The advantage of obtaining continuity of lines of beams or girders by welded connections lies in the fact that the designer can save weight in the structure. For example, in the 790-ton Sharon building, 51 tons of steel was saved by designing floor beams and header girders for continuity. The continuity of the girders through the columns was obtained by welding continuity plates in the columns in line with the top flanges of the girders. That this construction will produce continuity is illustrated by Figs. 10 and 11, which show failure by crippling of the *I*-beam web without any sign of weld failure whereas if the plates in the column are omitted as per Fig. 12, the column web will fail as indicated. The loads in these cases being 70,000

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lb. for the former and 53,400 lb. for the latter. The load deflection curves for Figs. 11 and 12 are shown by No. 2 and No. 4, respectively, of Fig. 13.

The application of continuity and reduction of connection details for the design of the first arc welded truss-type railroad bridge Fig. 14 resulted in a saving of 33½ per cent by weight in the steel required in the structure. The welded bridge involves 80 tons of steel whereas the riveted design requires 120 tons of

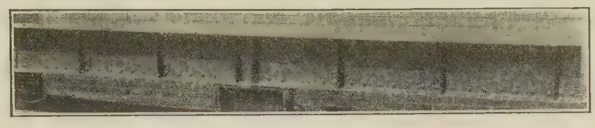

FIG. 1—RIVETED GIRDER

Girder 15 ft. long, 14-15/16 in. deep, weight 798 lb. Four flange angles 4 by 3 by 5/16 in. 16 web stiffener angles 3 by 2 by 1/4 in. 12 filler plates 2-1/2 by 5/16 in. and two 5 by 5/16 in. Web plate 14 in. by 5/16 in. Performance is shown in Fig. 3, curve No. 20.

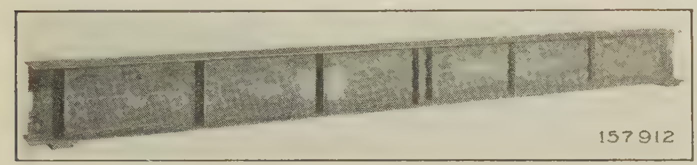

FIG. 2—ARC-WELDED GIRDER

Girder 15 ft. long, 14-3/4 in. deep, weight 656 lb. Two flange plates 10 in. by 3/8 in. 16 web stiffener plates 3 by 1/4 in. Web plate 14 by 5/16 in. Performance is shown in Fig. 3, curve No. 21.

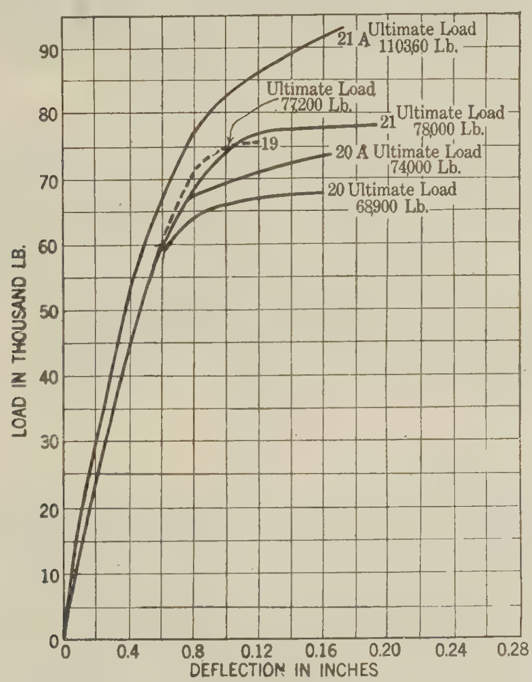

FIG. 3—LOAD-DEFLECTION CURVES OF RIVETED AND WELDED GIRDERS SHOWN IN FIGS. 1 AND 2

Curve 20A is a specimen duplicating the riveted girder in Fig. 1. Curve No. 19 is a specimen using identical material except that the connections were made with weld metal instead of rivets which reduced the weight of complete specimen to 785 lb. instead of 798 lb. Curve No. 21A is a specimen similar to arc-welded girder shown in Fig. 2, except that 4 additional web stiffener plates were used and all stiffeners were made 4-1/2 in. wide; also a top cover plate 9 in. by 5/16 in. by 6 ft. long was added, making the total weight 795 lb.

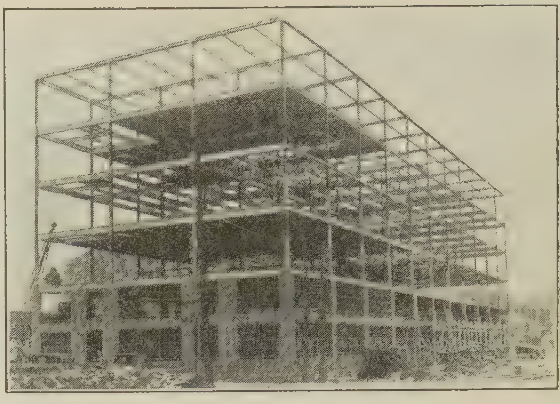

FIG. 4—LARGEST ARC-WELDED BUILDING PRODUCED TO DATE

Five stories and mezzanine floor 70 ft. by 220 ft. by 80 ft. high, 790 tons of steel; saving 95 tons of steel since a riveted building of same design would require 885 tons of steel. Location, Sharon, Pa.

FIG. 5—VIEW DOWN CRANE RUNWAY OF 790-TON ARC-WELDED BUILDING

Showing 9-ton girders made up of plate material, only saving 2 tons of steel as each would require 11 tons of steel for riveted construction.

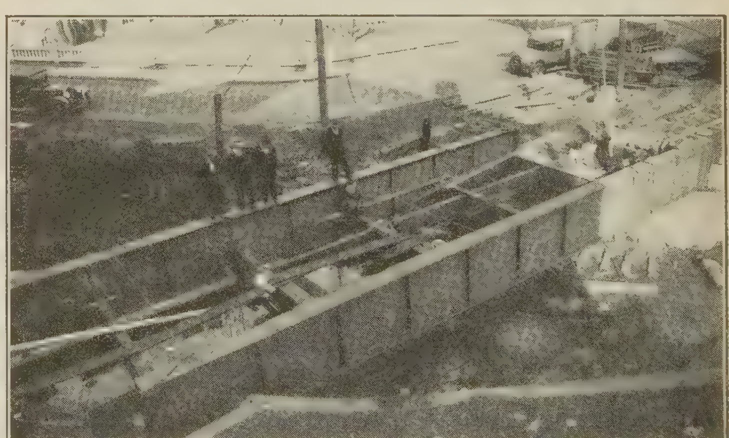

FIG. 6—ALL ARC-WELDED RAILROAD BRIDGE OF THROUGH-GIRDER TYPE

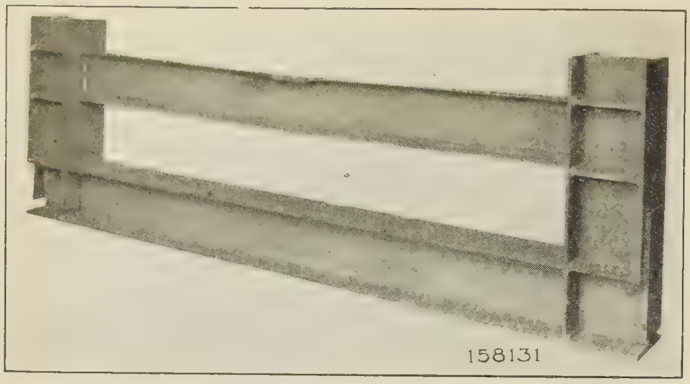

Fig. 7—Arc-Welded Beam

Beam member is a 9 in. 21.8 lb. 7 ft-11-3/8 in. long welded at ends to 10 in. H columns 49-1/2 lb. per foot. Performance shown by Fig. 9 curve No. 8.

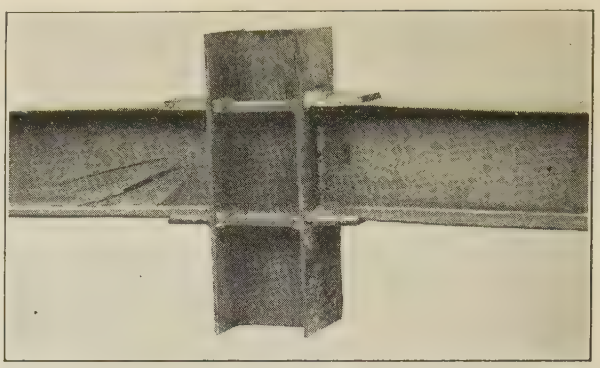

Fig. 10—Welded Beam Construction

Two cantilever 9 in. Bethlehem I-beams 20-1/2 lb. secured to 8 in. H column 32 lb. using seat angles 4 in. by 3 in. by 3/8 by 5 in. long, top reenforcing plates 4 in. by 1/2 in. by 4-1/2 in. long. Continuity plates, 3 in. by 5/8 in. by 6-5/8 in. long located in column, give the effect of making beams continuous through the column. Failure took place by crippling of beam webs. Performance shown in Fig. 13 Curve No. 2.

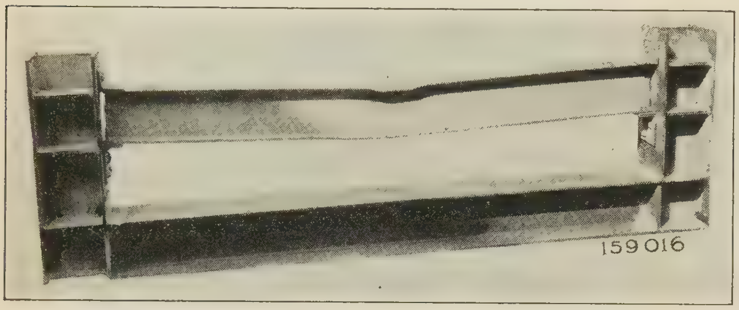

Fig. 8—Riveted Beam

Specimen same as shown in Fig. 6, except that beam is secured to column by 1/2 in. thick angles and 20 rivets 3/4 in. diameter. Performance shown by Fig. 9 curve No. 9.

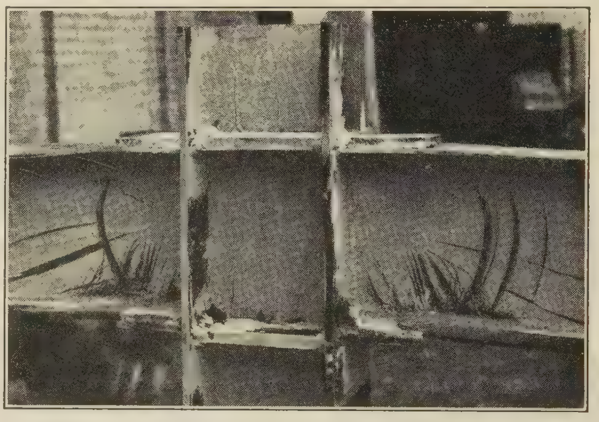

Fig. 11—Close-Up of Specimen Duplicate of Fig. 11

Shows stress lines on beam webs and no failure of welded connections. This specimen was coated with cement to accentuate the stress lines. Performance shown by Curve 2 of Fig. 13.

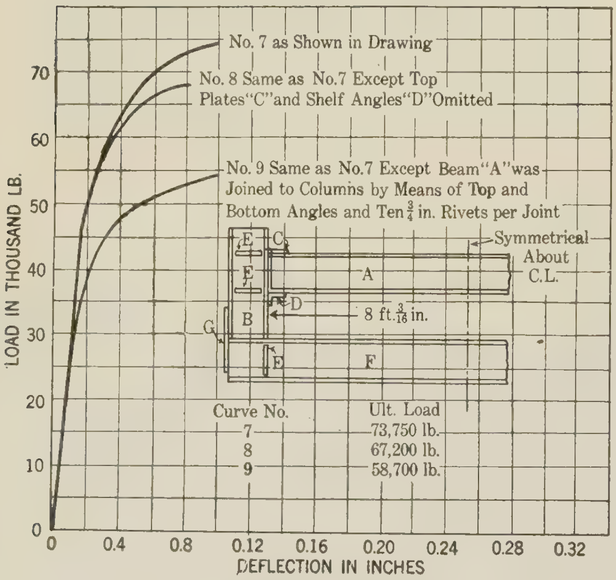

Fig. 9—Load-Deflection Curves of Beams in Figs. 7 and 8

Also Curve 7 shows a specimen similar to Fig. 7 except that seat angles *D* 4 in. by 3 in. by 3/8 in. by 5 in. long and top plates *C* 4 by 7/16 by 5 in. long were used as shown in sketch.

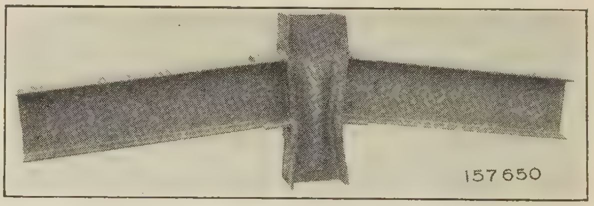

Fig. 12—Specimen Similar to Fig. 11 Except Continuity Plates were Omitted in Column

As a result of omitting continuity plates the column web buckled. Performance shown in Fig. 13 Curve No. 4.

steel. In the case of the welded design, the connection details are only about 5 per cent of the weight of the structure, whereas the connection details for the riveted design are about 30 per cent of the weight of the structure.

Where corrections in, or additions to, existing structures are to be made, the arc process will show tremendous savings, and as a result, much work of this type, such as the reenforcing of the Great Western Rail-

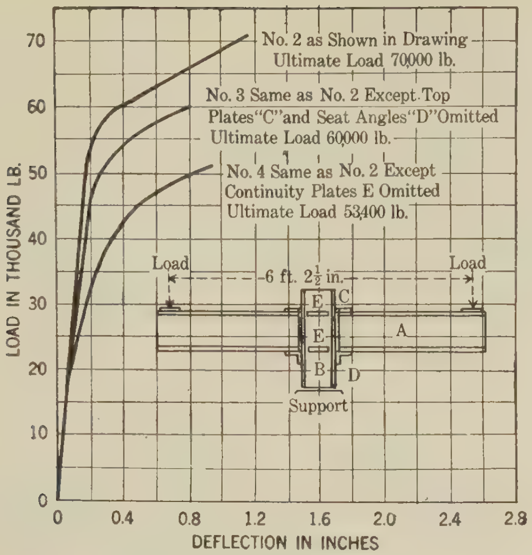

Fig. 13—Load-Deflection Curves of Specimens in Figs. 10 and 12

Also Curve 3 shows a specimen similar to Fig. 10 except that no seat angles or top reenforcing plates were used.

Fig. 14—First Truss-Type Arc-Welded Railroad Bridge at Chicopee Falls, Mass.

Welded bridge uses 80 tons of steel. Riveted bridge design specified 120 tons of steel.

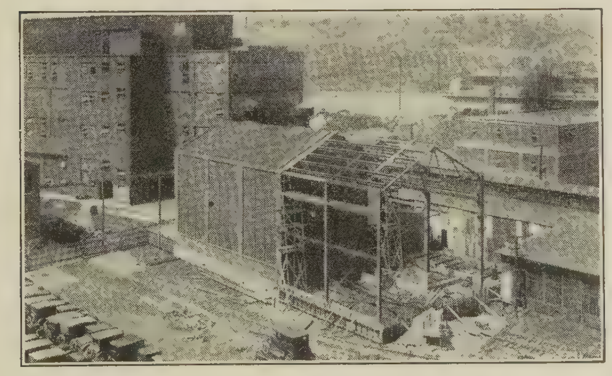

Fig. 15—Two Bays Being Added by Arc Welding to a Small Arc-Welded Building

Making structure 40 ft. by 100 ft. by 40 ft. to tops of columns. A saving of over 10 per cent was made compared with estimated riveted cost.

road Bridge, at Leavenworth, Kansas, over the Missouri River, has been performed recently. In this case, over 110 tons of plate material, etc., were added to the structure at a figure considerably below the riveting cost.

In the case of the 3-bay welded building, Fig. 15, it was decided to add two bays. To do this, only a relatively small amount of outside masonry was removed to permit of the welding being done as illustrated by Fig. 16.

The major saving in this class of work is in the elimination of drilling holes for rivets and tearing away masonry on the rear side of the members to permit backing up the rivets while being driven.

Due to its many merits, such as lower costs, absence of noise, etc., the arc welding process will undoubtedly come into greater and greater use. The information which is accumulating from its use on relatively simple buildings will make it available in combination with

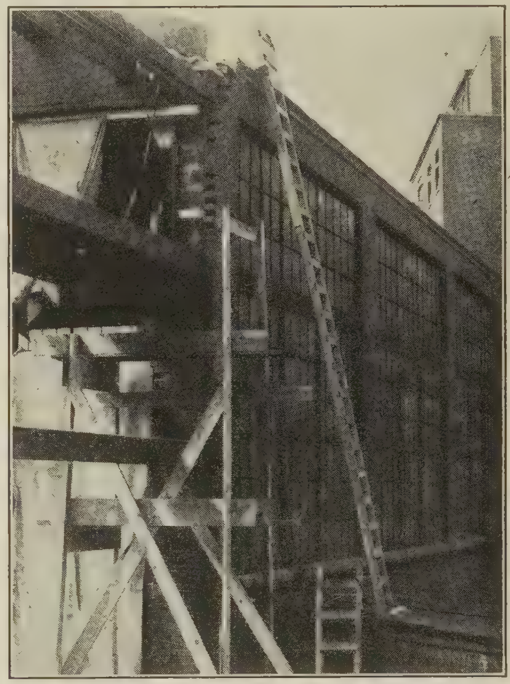

Fig. 16—Close-up View of Addition, Fig. 15

Shows small amount of disturbance in masonry where members are added to an existing structure by arc welding.

riveting for larger and more complicated structures, and should lead eventually to the possibility of its use almost exclusively on the largest and most complicated structures built of structural steel.

Addressing the Electric Club of Toronto recently, A. E. Davidson, engineer of the transmission department of the Hydro-Electric Power Commission of Ontario, forecast the use of airplanes to patrol the 230-mi., 220-kv. power line from the Gatineau Power Company's developments on the Gatineau River to Toronto, when construction of the line is completed. Much of the area through which the transmission line will run is rough and inaccessible, and inspection by air would be more rapid and more thorough.

Abridgment of

The Impedance Relay
Developments and Application

BY H. A. McLAUGHLIN[1] and E. O. ERICKSON[1]

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*This paper reviews the developments made in the impedance relay since its introduction in 1923. A brief review is given of its construction and operation, with special emphasis on the methods of obtaining proper potential for the restraining elements without the use of high-voltage potential transformers. The use of potential from condenser-type bushings is discussed. To make possible the use of low-voltage potential, methods of compensating for the voltage drop through power transformers and for the shifting of the secondary neutral point have been developed. These methods are described. Some special applications of the relay are also discussed.*

* * * * *

SINCE the impedance relay was first described in an Institute paper in 1923,[2] a large number of them has been applied to transmission systems both in this country and abroad. The increasing size and complexity of systems due to the many interconnections being made is responsible for the increasing use of this relay. The use of the former methods involving over-current and directional relays is difficult in interconnected systems having several generating stations, some of which may operate only a part of the time. In systems of this sort, the changes in direction and magnitude of the fault current may ruin entirely the selective current and time settings used with over-current and directional relays. The former protective schemes also become undesirable even on systems comparatively simple but having a number of stations in series. This is due to the fact that the relays have to be given graded time settings, which are a minimum at the end of the loop or line and which increase at each station as the generating station is approached, with the result that the most severe faults, (those occurring near the generating stations), are left on the system sometimes for several seconds. With high standards of service to be maintained, such a condition is most undesirable.

During the past few years, a great many improvements in the relays have been made, greatly widening its field of application. Some of these improvements have been described before,[3] but for the sake of completeness, they will be mentioned in this paper. Much experience has been gained in the application. The difficult and important problems of obtaining the necessary potential for these relays has received a considerable amount of attention.

1. Both of the Westinghouse Electric and Manufacturing Company.

2. L. N. Crichton, *The Distance Relay for Automatically Sectionalizing Electrical Networks*, A. I. E. E. Jl., August, 1923, Vol. 42, p. 793.

3. "Developments in the Impedance Type Relay." *Electric Journal*, Feb. 1927, J. V. Breisky and H. A. McLaughlin.

Presented at the Regional Meeting of the A. I. E. E., St. Louis, Mo., March 7-9, 1928. Complete copies upon request.

Construction and Operation

The impedance relay is quite similar in appearance to the well-known induction disk over-current relay except that a voltage actuated restraining element has been added. The restraining element acts directly on the contact mechanism and is connected to the over-current element through a lever arm and spring. Fig. 1

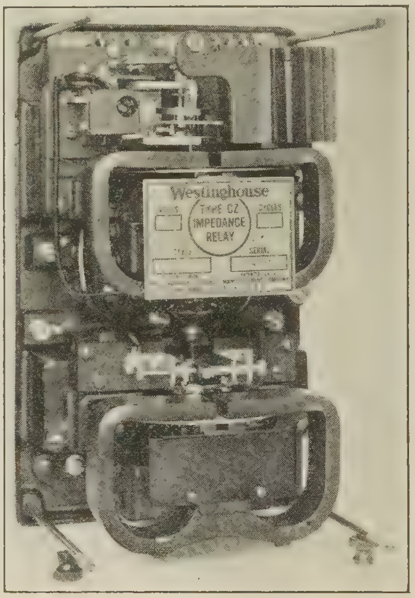

Fig. 1—Impedance Relay Showing Details of Construction and Directional Element Mounted in the Lower Part of the Relay

shows the mechanical features of the relay. When the current in the over-current winding exceeds a predeterminal value, the disk is caused to rotate. This disk is damped by a permanent magnet so that its speed is approximately proportional to the magnitude of the current. The rotation of the disk winds up the spring, one end of which is fastened to a countershaft geared to the disk shaft. A rocker arm pivoted at its center and mounted directly above the disk is connected to the other end of the spring by means of a

lever arm. The rocker arm has the moving contact on one end, and suspended on the other end, the core of the restraining element. The pull of the voltage coil, which opposes the closing of the contacts, is directly proportional to the applied voltage. For any given applied voltage, the spring must be wound a definite amount before it will overcome the restraint and close the contacts. The speed with which the spring is wound to this definite amount is dependent upon the magnitude of the current; and since the restraint is directly proportional to the voltage, the time of operation is proportional to the impedance. Then, by properly setting the relays, selective operation may be obtained whereby the relays nearest the fault will act before any others. The time of operation, also, will be nearly independent of current so that this action will not depend upon the operating conditions as long as the operating point of the relay is exceeded.

It will be noticed that where protection against both line-to-line and line-to-ground faults is desired, it is necessary to use two relays per phase, one restrained by a delta voltage and one by a star voltage. This is necessary since, by a fault, either one of these voltages may be reduced to a very low value without reducing the other more than approximately 50 per cent. For use in special cases where space is restricted, a duplex relay has been developed which combines in one unit two restraining elements operating on the same overcurrent element.

The ordinary directional element may also be combined with the impedance element to give a relay which will operate to trip its breaker when the current flow is in a predetermined direction. This directional element is shown in the relay in Fig. 1.

Adjustments

There are two adjustments available for setting this relay, a current and a voltage adjustment. The current taps are similar to those on the usual overcurrent induction relay. Adjustment is made by changing the position of a set screw in a connector block, thus changing the number of turns on the main coil. This fixes the minimum current at which the relay will operate, and is determined mainly from a consideration of the minimum short-circuit current existent with a fault on the system. The voltage adjustment consists of inserting resistance in series with the restraining coil in order to cut down the voltage actually applied to the coil. These two adjustments used in conjunction make it possible to set the relay to operate in a short time irrespective of the impedance of the line to be protected.

In the original relay, resistors were included in the relay case, with three voltage taps, similar to the current taps. It was soon found, however, that the range provided by these three voltage taps was insufficient, especially since the current adjustment must be made in such a way that the minimum short-circuit current gives a relay current of at least 200 per cent tap value. This requirement often necessitates the use of the four- or five-ampere tap, leaving it entirely to the voltage taps to obtain the proper adjustment for a line of high or low impedance.

The External Resistor

In order to get a range of voltage taps wide enough to cover all conditions encountered, an adjustable resistance unit known as the external resistor was designed to be used in conjunction with the relay. By the use of this resistor and the increased number of current taps made possible by the removal of the voltage taps from the relay case, very accurate settings may be obtained with lines of various lengths and a wide range of short-circuit currents.

Directional Control

One of the most recent improvements precludes the possibility of this relay operating incorrectly on account of sudden reversals of power flow, or a surge of synchronizing power set up in a system when a faulty line is disconnected by other relays on the system. The operation of the impedance element is controlled by

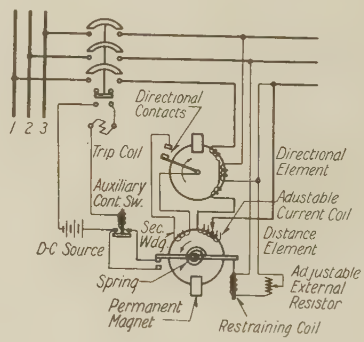

Fig. 6—Schematic Diagram of Impedance Relay Showing Directional Control of Impedance Element

that of the directional element; in other words, the direction of power flow must be in the correct direction for tripping and must remain so for a sufficiently long time for the impedance element to complete its operation before it can close its contacts. Thus it will be seen that the relay cannot be operated by sudden reversals of power such as will occur during the readjustment of a system when a fault is cleared. It will be noticed that even though these surges should be of considerable magnitude and duration, the restraining action of the impedance voltage immediately becomes predominant after the removal of a fault from the system.

This improvement was accomplished by connecting the directional contacts in the secondary and upper-pole circuit of the impedance element current electromagnet, making it necessary for these contacts to be closed before the impedance element disk can commence to rotate. In order to make this change feasible it was

necessary to redesign the secondary winding, so that a sufficiently small current and a high enough voltage would be obtained to prevent any error due to contact resistance. The fact that the directional contacts must close before the impedance element can start to function makes it possible to set them very close without danger of an incorrect operation due to rebound or jarring. How the directional control is obtained is shown in Fig. 6, the schematic diagram of a relay.

Voltage and Current Requirements

In order that under fault conditions, the impedance measuring element at a station shall determine its tripping time according to the impedance of the intervening line between the station high-voltage bus and the fault, it is necessary that this element be supplied with the following quantities:

a. Current proportional to the line current.

b. Voltage proportional to the line voltage at the station.

1. Voltage between conductor and ground—for phase-to-ground fault protection.

2. Voltage between conductors—for interconductor fault protection.

Current transformers of the dry type, oil-insulated wound-type, or bushing-type satisfy the demands for current correctly representative of conductor current, and their application will not be discussed further here.

Sources of Voltage. At stations transmitting at generated voltage, there is but one source to be considered,—the transmission line itself.

At stations transmitting at other than generated voltage and at transformer substations there are obviously two main sources of voltage: (a) The high-tension bus, (b) The low-voltage bus.

The use of high-voltage potential transformers generally insures the delivery to the impedance relays of voltages correct in every respect. On very high-voltage lines, the cost of high-voltage potential transformers becomes prohibitive and in such cases, other methods by which correct voltage may be obtained become economical. The direct use of low-voltage potential transformers will give, in many cases, incorrect operation. The reasons for this will be pointed out presently.

Potential from Condenser Bushings. Recently, a method of obtaining potential from condenser-type bushings, (used in circuit-breakers and transformers), has been developed for synchronizing,[4] which also can be used on extra high-voltage systems for relaying if the volt-ampere burden is sufficiently low. Thus, in general, a voltage of sufficient accuracy for relay work will be obtained. Since the phase position and not the magnitude of the voltage required for the directional element is of importance, it may be advantageous in certain cases to reduce the burden on the condenser bushings by connecting only the restraining elements to them and obtaining the directional element potential from the low-voltage bus.

Use of Potential from the Low-Voltage Bus. Under certain conditions, the potential may be taken from the low-voltage bus in a transformer station and directly applied to the relay. Generally, however, correct operation will not result. To take care of these cases, two systems of compensation have been developed which will allow the use of low-voltage potential where this is more economical than using high-voltage potential transformers. The first of these compensating schemes was suggested by several people. The second is the result of S. L. Goldsborough's work. Mr. Goldsborough also did the development work on both types.

Type KX Compensator

Basic Principle. In principle, the type KX compensator is similar to the line-drop compensator commonly in use on feeder regulator installations. The

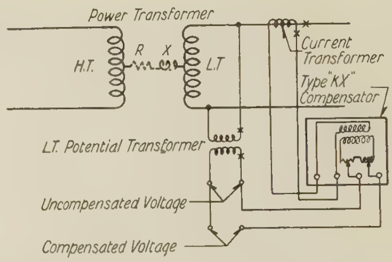

Fig. 9—Elementary Diagram of Type KX Compensator Applied to a Single Two-Winding Power Transformer

KX compensator delivers at its two output terminals a voltage adjustable in phase position and magnitude with respect to the current supplied to its two input terminals. By means of four dials, coarse and fine adjustment of both in-phase and quadrature voltages are made available, the dial setting being rated in volts for a primary or input current of five amperes. For the purpose of illustration, a KX compensator is shown (Fig. 9) as functioning to compensate for the drop over a single two-winding power transformer.

The uncompensated voltage delivered at the instrument side of the potential transformer does not bear a constant relation to the voltage on the high-tension side of the power transformer, being higher or lower than its normal ratio depending upon the direction of power flow through the power transformer. The extent to which it deviates from its proper value is a function of the transformer impedance and of the magnitude of the current flowing through the power transformer winding.

The KX compensator is shown being supplied with current at its input terminals proportional to the power transformer current.

When the compensator dials have been set according

4. E. E. Spracklen, D. E. Marshall and P. O. Langguth, *The Use of Condenser-Type Bushings in Connection with Synchronizing Equipment,* 1928 Winter Convention, A. I. E. E.

to the resistance and reactance of the power transformer, the voltage component representing the drop over the power transformer is accounted for; and a final compensated voltage is made available, satisfactory for use on the impedance relay restraining element, since it bears a constant relation to the high-voltages and is independent of direction of power flow.

Typical Three-Phase Application—Two-Winding Transformers. The application of type KX compensator to a star-delta bank of power transformers with high-voltage star neutral grounded is shown in Fig. 10.

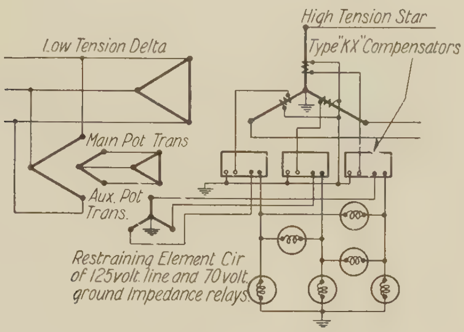

Fig. 10—Connection Diagram Showing Application of Type KX Compensations to a Star-Delta Connected Transformer Station, with Neutral Grounded, Employing Low-Voltage Potential Transformers

Three compensators are shown, each one serving to compensate for the interwinding impedance of one transformer in the bank.

With the arrangement as shown, compensation is correct for both interconductor faults and conductor-to-ground faults, the particular relay or relays actively concerned with clearing the fault being supplied with voltages correctly representative of the conditions on the faulted high-voltage side.

The KY Compensator

The KY type compensator has been designed to nullify the effect of the shift in the neutral, which takes place on the ungrounded star high-voltage side of the power transformer bank at a substation on a grounded system, thereby permitting the use of low-tension potential transformers at such stations.

In principle the KY compensator is similar to the KX compensator, except that it is a potential device. The KY compensator delivers at its two output terminals a voltage which for the general setting is 19.3 per cent of, and in quadrature to, the voltage impressed across its two input terminals.

When three such devices are connected as shown in part *a* of Fig. 11, (in which the potential transformers secondaries are the same as those shown in Fig. 8 part *a*), the undesirable voltage *a*, *o* shown in the last vector diagram of part *c* of Fig. 8 (and shown on a larger scale in Fig. 11 part *b*), is completely nullified, resulting in zero voltage being delivered to the relay as is correct for the particular fault described. The voltage P_a, T_a combining with the voltage *a*, *o* produces voltage T_a, *o* (zero volts), which is correctly representative of the actual faulted conductor voltage above ground at the time of the assumed dead fault-to-ground.

For ground faults which do not result in zero voltage at the point of fault it can be shown that the KY compensators still function correctly, in that the voltage delivered to the active relay bears the same ratio to the voltage it is to represent as it does under normal operating conditions. Normally, when using type KY compensators, the restraining elements of the impedance ground relays receive a voltage equal to two-thirds of the full star voltage. The fact that the above mentioned ratio is the same under all fault conditions permits correct operation to take place, the existence of the two-thirds ratio being taken into account in setting the impedance ground relays when associated with type KY compensators.

Special Applications

On some grounded neutral systems, the current caused by an accidental ground may vary over wide ranges, due either to operating or soil conditions. The use of impedance ground relays, in conjunction with a directional ground relay operating on residual current and voltage, which can be made sensitive since it is independent of load current, offers the advantage of providing fast clearing of heavy grounds by the impedance relays and the slower, but still selective clearing of the low-current faults by the more sensitive residual directional relays having graded time settings.

In some systems, due to the long lines and the small amount of generating capacity on the system during

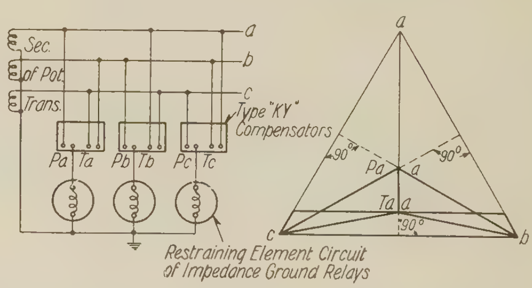

Fig. 11—Part *a*. Connection Diagram Showing Application of Type KY Compensators. This Diagram is a Continuation of Part *a* of Fig. 8

Part *b*. Vector Diagram Showing the Uncompensated and the Compensated Voltage Vectors

certain periods, the minimum short-circuit current may be less than the maximum full-load current. For use on such systems, an impedance relay having low-current taps (used in conjunction with a fault detector), has been developed. Under normal conditions, the impedance relay is kept deenergized. On the occurrence of a fault, the fault detector makes the impedance relay operative and it tends to operate the breaker in accordance with the distance from the fault. The

fault detector is responsive to an overcurrent or an undervoltage of predetermined values, all faults being accompanied by one or the other of these conditions.

Conclusions

The impedance relay, while it is relatively new in the field of protective relays, is already being used quite extensively both in this country and abroad. Because of the impossibility of obtaining satisfactory results with overcurrent and directional relays in many cases, and the objectionable time delays involved even when selectivity can be obtained, the impedance relay is receiving more and more consideration. This is a step in the right direction since the impedance principle involves a relay independent of system conditions and dependent on direction of current flow for its operation, and on distance from the fault for its time. Many improvements and developments have been made as the result of operating experience, which also has resulted in a better understanding of its operation on the part of operating engineers, many of whom now use the impedance relay as their standard type of protection.

Abridgment of

Interconnection and Power Development in Chicago and the Middle West

BY H. B. GEAR[1]

Fellow, A. I. E. E.

Synopsis.—The development of power stations in the Chicago District is described, showing how small stations have been replaced, and the energy supply for light, power, and traction consolidated by the use of high-voltage lines.

The interconnections between stations and the developments of recent years and for the immediate future are outlined. This includes cables at 66,000 and 132,000 volts, with circuit capacities of 60,000 kv-a.

A station in Central Illinois, near the coal supply, is being tied in with the Chicago District.

Interchange of energy between companies is conducted under an agreement, which is an important factor in the success of interconnection. Some of the operating problems are outlined briefly.

The development of power producing equipment for the supply of electrical energy in utility service during the past quarter of a century has been greatly influenced by the development of electrical transmission of energy which has accompanied it.

The ability to send energy economically from a principal point of production to numerous points of distribution was the prime factor in a period of development in which many small pioneer stations were replaced by a few larger power stations, with a considerable gain in economy of construction and operation.

Development of Interconnection

The use of interstation tie-lines has been in general practise since power station development reached a point where two stations under the same management were located in such proximity as to make interconnection practicable.

Such interstation lines were operated at the voltage of the generator. Later, the voltage used for transmission of the supply of energy to substations was more often employed.

Interconnections of this type were of relatively small capacity until the size of generator units became such that an excessive number of circuits was required to provide an adequate reserve for the larger units.

In the Chicago District such interconnections were established between the Fisk Street and Northwest Stations, a distance of about eight miles, at 12,000 volts.

Other interconnections were made between stations is suburban districts at 33,000 volts, with overhead lines forming a part of the general transmission system.

These interstation lines were, however, of minor importance when compared with the transmission capacities necessitated by the rapid growth of the past 10 years.

The Calumet Station was located at South Chicago, 13 mi. southeast of the Fisk Street Station, to provide a supply of energy for the great industrial district in that section of Illinois and Indiana. However, the unexpectedly rapid development of load made it necessary to transmit a considerable part of the energy produced there to the Fisk Street zone. This called for a group of lines having a capacity of the order of 100,000 kv-a., and, since these must be underground cables, it was very desirable that the capacity of individual cable units be as great as it was practicable to secure at that time from manufacturers of cables.

This was accomplished by the selection of a 33,000-volt, three-conductor cable unit, having a capacity of 15,000 kv-a., and these cables became the first link in a chain of interstation lines of high capacity, which have been installed since 1921 between all of the principal generating stations in the Chicago District.

1. Asst. to Vice-Pres. Commonwealth Edison Co.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Feb. 13-18, 1928. Complete copies upon request.

From Northwest Station a 33,000-volt cable of foreign manufacture was laid northward to Evanston to interconnect with 33,000-volt overhead lines of the Public Service Company of Northern Illinois. This formed an interconnection between Northwest Station and the Waukegan Station, some 30 mi. north of the Chicago city limits, and this cable has continued to operate at 33,000 volts without serious trouble.

In 1924 the first of a system of steel tower lines on private right-of-way, operated at 132,000 volts, was constructed from Calumet Station to the Joliet Station, and to the Gary steel making district in Northern Indiana. A little later this was extended to Michigan City, some 50 mi. east of the Chicago city limits.

Following the extension of this line to Michigan City, a connection was completed from that point to the Twin Branch Station of the Indiana and Michigan Electric Company, near South Bend, Indiana.

From Twin Branch, other lines extend east to Ohio, and thence to West Virginia and Pennsylvania. It was through this interconnection that the paralleling of a group of systems reaching eastward to Massachusetts was accomplished (for a few minutes) some months ago.

Continuous parallel operation of the Chicago District with the Ohio system is fairly stable when more than 10,000 kv-a. is being transferred from one system to the other.

More recently, parallel operation was carried on for over an hour with the Ohio system, while it was tied in with lines extending through West Virginia, Tennessee, and Georgia to Pensacola, Florida. The fluctuations were not greater at the Chicago end than under normal operation with the Ohio system only.

Sufficient experience has been had to make it apparent that when the weaker links have been increased to be comparable with the stronger, these systems can be operated in parallel successfully for such periods of time as may be necessary to meet the needs of operation during emergency transfers of energy.

Current Developments

In view of the rapid absorption of the ultimate capacity available at the Crawford Avenue site, where six of the 10 ultimate units will have been installed within five years, sites have been acquired at points on the shore of Lake Michigan for future power development. (Fig. 3).

The first of these to be developed was Waukegan, 40 mi. north of the center of Chicago, and about midway between Chicago and Milwaukee, where three units, aggregating 110,000 kw., are now in service.

This station is connected to Chicago by a 132,000-volt line, with a capacity of 60,000 kv-a., which is overhead from Waukegan to the Chicago city limits; thence to Northwest Station it is underground. This six-mile link of 132,000-volt cable is one of two pioneer installations put into service in 1927, the other being in the city of New York.

There is also a 132,000-volt overhead line, from Waukegan to Milwaukee, which acts as a reserve to the systems at either end.

Power developed at this site is used as needed in the neighboring territory and the northern part of the Chicago system, where the load exceeds the capacity of the Northwest Station.

Another site on Lake Michigan is at the Indiana-Illinois state line, on the Indiana side. The city of Chicago adjoins this property on the westerly side.

The first unit of this state line station is under way and is to consist of a three-part unit, with high- and low-

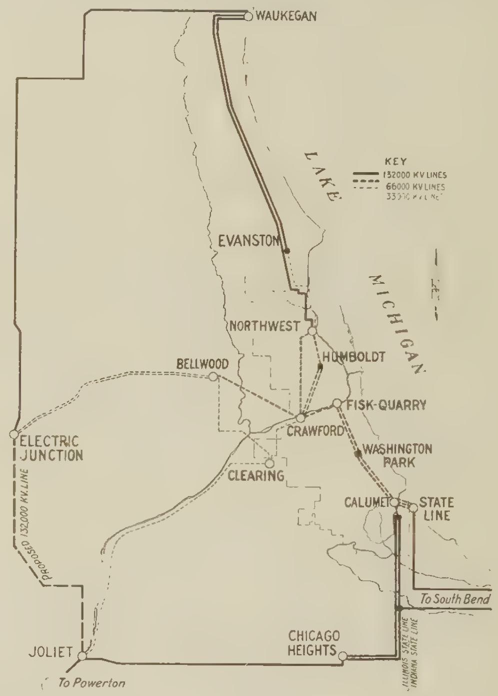

Fig. 3—Interconnection Chicago District, 1929

pressure elements so arranged as to be the operating equivalent of two units, aggregating 208,000-kw. capacity. This site will permit the installation of five units of this capacity, or a total in excess of 1,000,000 kv-a. The first unit is planned to go into service in 1929.

This station will be unique in the Chicago District, in that all of its energy will be transformed to higher voltages and sent to other zones for distribution and utilization.

Energy sent into Chicago will be carried by underground cables having a capacity of 60,000 kv-a. per circuit at 66,000 volts.

Energy sent into the outlying territory will be carried by overhead lines at 132,000 volts, and to the neighboring cities of Hammond and East Chicago at 33,000 volts.

Within the city of Chicago, the use of 66,000-volt cables for transfer of large blocks of energy between stations was adopted in 1926, and several such lines have been in satisfactory service for more than a year between Crawford Avenue Station and the Fisk Street and Northwest Stations.

A new type of distribution center, receiving energy at 66,000 volts and distributing it at 12,000 volts in blocks of 4000 to 8000 kv-a., has been developed as a means of decentralizing the amounts of energy concentrated at generating stations on 12,000-volt busses.

These distribution centers will have an initial transformer capacity of 120,000 kv-a., and will distribute ultimately, about 200,000 kv-a. each. Being located midway between generating stations, they will effect economies in 12,000-volt cable which will offset other costs and result in a net saving in investment.

The first of these distribution centers to be known as Washington Park will come into service in 1928, and

Fig. 4—Power Interchange at Peak Hours, Chicago District, 1928

will be located midway between the Fisk Street and Calumet Stations on the south side of the city.

In Chicago and vicinity, the interchange of energy between power stations for the winter of 1928-9 at the peak hour is graphically depicted in Fig. 4.

In this chart, the load in the station zone is indicated by the shaded portions. Where the zone load is greater than the station capacity, the overload is indicated by cross-hatching. The area of the circles is proportionate to the capacity of the respective stations.

Rights-of-way have been secured for overhead lines at 132,000 volts, connecting Joliet with Crawford Avenue Station, and for an outer belt line between Joliet and Waukegan, to be constructed as load conditions may make their installation advantageous.

Much discussion and calculation has centered about the idea that energy should be produced at points near to coal mines, and sent thence by high-voltage lines to the electricity market, instead of sending the fuel to stations located in the districts where the electrical energy is produced.

In the Chicago District, the major part of the fuel supply is brought from mines 200 mi. or more distant, and the problem of delivering hundreds of thousands of kw. of energy by overhead transmission lines at such distances is by no means simple.

Coupled with that problem is the one of finding a place where a supply of water for condensing purposes is present, as well as a supply of coal.

In Central Illinois, a location has been found which approximates this combination.

A site has been chosen on the Illinois River, about 14 mi. southwest of Peoria and some 70 mi. northwest of the coal fields, from which the major supply of coal used in Chicago power stations is taken. A direct railroad connection from mines to this site has been provided.

This site has been named "Powerton," and is now being developed for two units of 55,000 kw. each, the first of which will go into service in the fall of 1928. (Fig. 5).

The development of an economical station in this locality not only provides for future growth in this part of Illinois, but will effect large savings in fuel and operation cost, by producing energy now generated in smaller and, for the most part, much less efficient stations. Most of these stations will be shut down, except for the peak-hour shift.

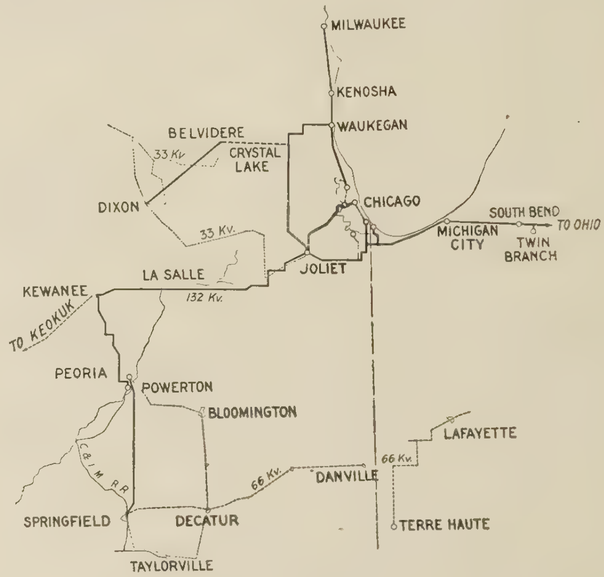

Fig. 5—Powerton District, 1928

The energy delivered to the cities north and east of Powerton will be transmitted by overhead lines at 132,000 volts.

Nearby cities will be supplied by connecting into the 33,000-volt system of lines now used for bulk supply in that part of the state, and through an overhead, 66,000-volt system to Springfield and cities easterly therefrom.

Basis of Operation

The use of reserve generating capacity and low-cost energy to the fullest practical extent is facilitated in the Chicago District by the provisions of a three-party interchange energy agreement, which pools reserve capacity and permits the flow of energy to

neighboring zones whenever the load in the immediate zone permits; or when the energy so transferred costs less than that produced in the neighboring zone.

The difference between the total capacity in the pool and the coincident maximum load of the three systems is taken as the group reserve.

The percentage of group reserve is taken as the standard and any company having a reserve percentage higher than the group percentage is compensated for the carrying charges on its excess station capacity, by the other company or companies whose percentage of reserve is less than that of the group. This permits the smaller companies to install larger units than would be possible if only the requirements of their individual systems were to be met, and thus gives them capacity for future growth at a lower investment cost, with higher operating efficiency.

A subcommittee of load dispatchers, meets weekly to arrange operating schedules for the transfer of energy from the more efficient stations to other zones at off-peak hr., to arrange a coordinated program of turbine outages for overhauling purposes, and, in emergencies, to confer by telephone and arrange relief where it may be required.

The conditions, as they existed in one of the summer months of 1927, will serve to illustrate the way in which the interchange energy agreement is accomplishing the result contemplated by the parties thereto.

Company	A	B	C	Total kw.
System maximum.......	864,300	139,800	44,700	1,041,000
Reserve capacity, kw.....	101,245	97,980	2,075	201,300
Reserve quota (19%).....	165,875	26,240	8,585	201,300
Excess and *Deficiencies.	*64,630	71,740	*6,510	..

Company "A" paid Company "B" for 64,630 kw. of reserve capacity, and Company "C" paid Company "B" for 6510 kw. of reserve capacity. Thus, Company "B" was reimbursed for an excess of 71,740 kw. in its reserve capacity.

During the same month, Company "A" delivered to Company "B" 9,135,000 kw-hr., Company "B" delivered to Company "A" (in other zones) 16,936,000 kw-hr., and Company "A" delivered to Company "C" 9,172,000 kw-hr.

Of the total of 35,243,000 kw-hr. thus transferred, about 19,000,000 kw-hr. were delivered at off-peak hour, and resulted in a saving in fuel consumed of about $19,000.00 in that month.

Summary of Results

The interconnection of power stations by lines of relatively large capacity has resulted as follows:

a. The size of generating units is increased, while the total capacity and reserve for the district is decreased;

b. The investment per kw. of capacity in generating stations and the total investment is decreased;

c. The consumption of fuel is reduced by ability to give the more economical units the "base load" of an entire district;

d. The reliability of service is enhanced by increased availability of the capacity and reserve in generating units, during emergencies and routine operating work, such as overhauling and repairing equipment.

Problems of Interconnection

It has been apparent, from the foregoing recital of experience with plants in the Chicago District, that there are some problems which require solution before an interconnected group may realize the advantages sought. These problems relate, chiefly, to the ability to control the division of energy between neighboring stations and to make delivery continuously when occasion requires.

The experience had thus far in the Chicago District indicates that these problems lie outside of the generating equipment almost entirely, and relate to the size, voltage, length and other characteristics of the interconnecting lines.

When line capacity is high, and lengths are short in proportion to the voltage of transmission, the transfer of energy between stations is readily accomplished by governor control of the generating units.

When lines are relatively long and have a capacity which is approached by the normal surges of synchronizing energy, which flow between the two sources of power, there is instability of operation, and lack of continuity is likely to result.

The presence of several successive transformations in a tie-line has the effect of increasing its impedance and is, thus, equivalent to an increase in length. More than two transformations (one each way) are to be avoided in such lines, if possible.

In longer lines and in lines where the direction of flow of energy is at different times in opposite directions, it is often necessary that means of voltage control be provided. These are required to permit the receiving station to operate its bus at a voltage level suited to the requirements of the circuits supplying energy within its own area of distribution.

Transformers with tap changers, adjustable under load, are finding a field of usefu lapplication in such situ ations.

At the higher voltages the use of synchronous condensers for voltage control are often found desirable through the ability to regulate the power factor of the system secured thereby.

Conclusion

In conclusion, it has been shown that interconnection and power development have already been well coordinated in some of the large centers of population.

The coordination of major points of power production by interconnections in a group of states is under way.

The next decade will see a continuing development of large power stations, joined by lines of high-voltage of great capacity, coordinating the supply of energy to great areas, as it has been done in metropolitan centers of population.

Abridgment of

Heat Losses in D-C. Armature Conductors

BY W. V. LYON[1] E. WAYNE[2] and M. L. HENDERSON[3]

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*Without doubt, it is generally believed that there are extra losses in the armature coil of a d-c. machine when it is undergoing commutation, but that during the major portion of the time, since the current is steady, the loss in the coil is correctly computed by squaring the value of the current and multiplying by the true or ohmic resistance of the coil. This view, however, is not correct. The disturbance in the coil current produced by the process of commutation persists throughout the cycle so that at no time is the current uniformly distributed over the cross-section of the conductor. Although the disturbance and resulting extra loss factor are greatest during commutation, the extra losses are present at all times, even while the current in the coil is steady.*

PART I

ALTHOUGH there have been excellent papers[5] on this problem of the armature copper loss in a d-c. machine, so far as the authors are aware, it has received no serious consideration in this country and it is not generally realized that the time-honored method of computing the armature copper loss does not give a correct value of the loss. Error may range from 10 or 20 per cent in a small machine to several hundred per cent in a large and poorly designed one. Thus the determination of this loss and the factors which influence it are matters of prime importance. Due to the process of commutation, the current in the armature coil of a d-c. machine is an alternating one which has a fundamental, and various harmonic components. The problem of an armature coil that carries a sinusoidal current has been investigated by several writers since Field[4] first published his solution of the problem. The experimental results[6] which have since been obtained agree so closely with the computations that we are warranted in extending the application of the theory to this problem of the heat losses in the conductors of a d-c. armature when not only the fundamental but all of the harmonic components are present in the current. Due to the fact that the losses produced by the higher harmonics in the current increase about as the square root of the frequency, the extra loss factor for a d-c. armature is greater than the extra loss factor for an a-c. armature under the same conditions of speed, poles, size and arrangement of the armature conductors. Laminated conductors are indispensable in the design of a-c. generators, but it is even more important to laminate and properly arrange the armature conductors of a d-c. machine.

One phase of the present investigation was to compare the observed and computed results when the current in an embedded coil (Fig. 1) is commutated so that it

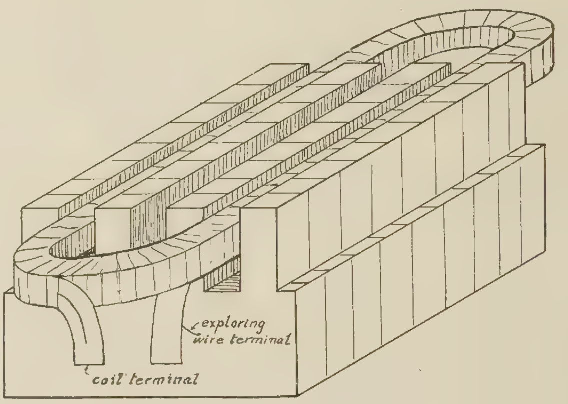

FIG. 1—GENERAL ARRANGEMENT OF COIL AND EXPLORING WIRE

varies as does the current in the armature coil of a d-c. generator. A typical curve showing the time variation of the current is shown in Fig. 2. The coil shown in Fig. 1 consisted of 51 turns of copper ribbon one inch wide by 0.0062 inch thick. Five No. 40 wires were attached to, but insulated from, the ribbon at uniformly spaced intervals. One of these wires was 1/16 inch from the upper edge of the ribbon; one 1/4 inch from the upper edge; one at the middle; one, 1/4 inch from the lower edge and one, 1/16 inch from the lower edge. The ribbon and the attached wires were then wound to form the coil, a cross-section of which is shown in Fig. 3. These exploring wires enable one to make a direct measurement of the current density at five different points in the ribbon. Inasmuch as an exploring wire and a filament of the ribbon in the same

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2. Swope Fellow in Electrical Engineering, 1926-27, Massachusetts Institute of Technology.

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4. *Eddy Currents in Large Slot-Wound Conductors*, A. B. Field, A. I. E. E., 1905, p. 761.

5. L. Dreyfus, "Zusätzliche Kommutierungsverluste bei Gleichstrommaschinen," *Elekt. und Masch.* XXXII, 281, 1914.

L. Dreyfus. "Die Theorie der zusätzlichen Kommutierungsverluste von Gleichstrommaschinen," *Arch. fur Elek.* III, 273, 1915.

L. Dreyfus. "Zusätzliche Kupferverluste durch Stromverdrangung bei Einankerumformern," *Arch. fur Elek*, IV, 42, 1915.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Feb. 13-17, 1928. Complete copies upon request.

horizontal plane link the *same flux*, the difference in their potentials is the resistance drop in this filament of the ribbon and is therefore proportional to the current density in this filament. The arrangement of the coil, commutator, and oscillograph vibrators is shown in Fig. 4. The current density vibrator was calibrated by sending a known value of steady current through the coil. Five calibrations were made, one for each exploring wire. The commutator was driven so that the current in the coil was reversed 120 times per

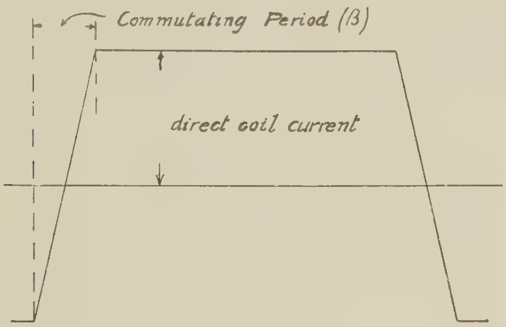

FIG. 2—CURVE SHOWING TIME VARIATION OF COIL CURRENT

sec., giving a 60-cycle variation. The oscillograms obtained are shown in Fig. 5a, b, c, d and e. These oscillograms show the current in the coil and the current density at each of the five points. The scale of the current is such that the curve also shows the average current density and may be compared with the actual current density. The computed time variation of current density at each point is also shown. The

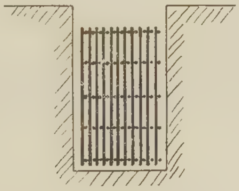

FIG. 3—CROSS-SECTION OF COIL AND EXPLORING WIRES

close agreement between the observed and computed values shows that, under the conditions existing during this measurement, the premises on which the theory is built—*viz.*, those adopted by Field—are amply justified.

The computed values of the current density were obtained in the following manner. The time variation of the current in the coil was first analyzed for its harmonic components. By means of the fundamental relation[7] between the current in the conductor and the current density at any point, the time variation of the current density at each point for each harmonic component of the current up to and including the eleventh harmonic, was determined. By combining the harmonic variations in current density at one point the

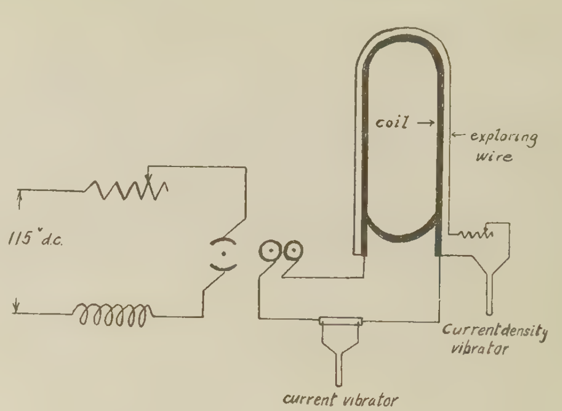

FIG. 4—ARRANGEMENT OF COMMUTATOR, COIL AND OSCILLOGRAPH VIBRATORS

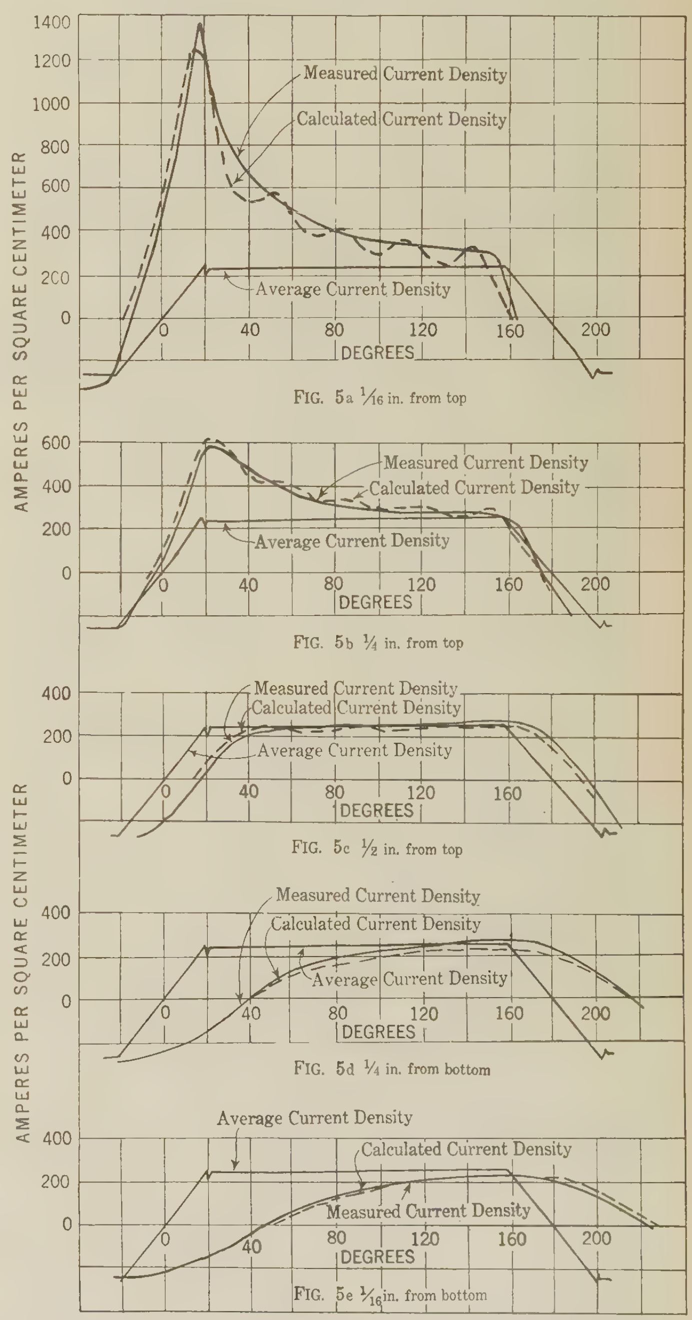

FIG. 5—a, b, c, d, e, OSCILLOGRAMS AND CALCULATED CURVES OF CURRENT DENSITY AT DIFFERENT POINTS

7. W. V. Lyon, *Heat Losses in the Conductors of A-C. Machines*, TRANS. A. I. E. E., 1921, Vol. 40, p. 1361.

resultant variation in the current density at the point was determined and plotted. The oscillograms show distinctly that the current density is greater in the upper portion of the conductor than it is when the current is sinusoidal; that the higher harmonics are practically confined to the upper portion of the conductor; that during the commutating period, the current is flowing in opposite directions in the conductor at the same

Fig. 5f—Wave Form of Coil Current When Loss Measurements Were Made

time; that at the beginning of each half-cycle the current is most unevenly distributed, but toward the end of the half-cycle the distribution has become nearly

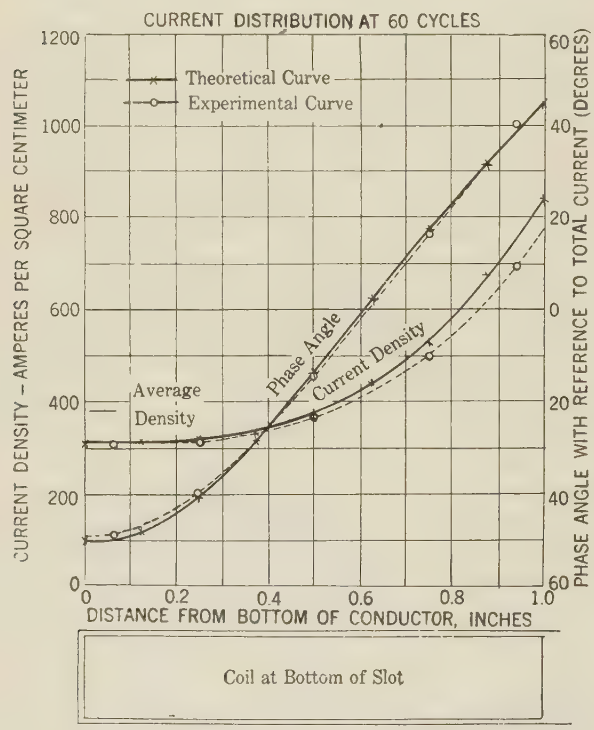

Fig. 6

uniform. In describing the phenomenon, it might be said that the continued reversal of the current, due to the process of commutation, produces a turbulence in the current flow of such a nature that the current distribution consists of a series of harmonic components, each one of which can be determined in the same manner in which the distribution is determined when the current variation is purely sinusoidal. This turbulence is not confined to the commutation period alone but continues throughout the cycle. The heat loss in the conductor is the sum of the losses due to the individual harmonic components of current. Each of these component losses can be determined by the same procedure that is used in computing the loss in an a-c. generator. Computation of the resistance ratio for a d-c. machine is thus a much more laborious process, than is the computation of the ratio for an a-c. generator. The resistance ratio may be defined in one of two ways, either as the ratio of the actual loss to the loss that would occur if the same coil current were uniformly distributed in the conductor, or as the

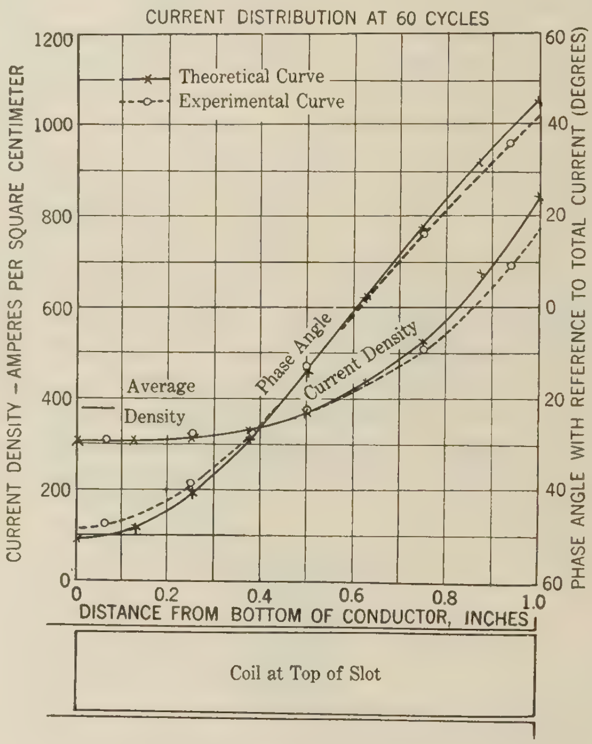

Fig. 7

Figs. 6 and 7—Comparison of Measured and Computed Current Densities

ratio of the actual loss to that as computed according to the standardization rules of the A. I. E. E. These ratios would be somewhat different. In our case the measured loss in the coil was 14.8 watts and the calculated loss, 14.4 watts. In the calculation, only the harmonics up to and including the 13th were considered. The loss due to the fundamental, or 60-cycle, component is 12.9 watts, showing that the loss due to the harmonics is 10.4 per cent of the total. When this measurement of power loss was made, a different commutator was used and the wave form of the coil current is shown in Fig. 5f. The maximum flux density in the teeth during these power measurements was approximately 1000 gausses.

There is another point of interest. It is the heat loss in the coil during the period of commutation. If it be assumed that the variation of the total current, and of the current density during the time of commutation is linear, an approximate value of the ratio of the actual heat developed to that which would be developed if the current density were uniform can be calculated. In our case this ratio is approximately 5; that is, during commutation the conductor acts like one having a resistance approximately five times as great as it actually is.

With 60-cycle sinusoidal current in the conductor the measured and computed resistance ratios are 1.66 and 1.61 respectively. Figs. 6 and 7 show the observed and computed current densities and their phase-angles with respect to the total current in the conductor.

All of these results seem to show that the original premises as stated by Field are so nearly true, even when applied to this problem of the commutated current, that the errors in the computation are scarcely of engineering importance.

When these principles are applied to the determination of the armature copper loss in a d-c. machine it must not be expected that the accuracy of the result will equal that attained in the case of the a-c. generator. There are two principle reasons for this: First, it is improbable that the variation of the current during the commutation period will be known with sufficient precision. Poor commutation may give rise to harmonics that will materially increase the copper loss. Second, in d-c. machines, coils which undergo commutation at slightly different times are placed side by side in the slot, producing a phase displacement between the components of the currents in these adjacent coil sides which is directly proportional to the order of the harmonic. Some of the higher harmonics will thus be approximately in opposition. This condition violates one of the Field premises, *viz.*, that the current density should be the same in any horizontal plane. Three approximate methods for computing the loss in this case are described in Part II of the paper.

The general principles here discussed can be applied also to the determination of the copper loss in a synchronous converter. If, for example, it be assumed that the current in the conductor is the sum of a sinusoidal component received from the a-c. side and a trapezoidal component, such as might flow in a d-c. generator, there will be a resultant fundamental component depending upon the a-c. input, the d-c. output, and a series of harmonic components, which depend only upon the d-c. output.

In conclusion, it is important to realize that the heating loss in the coil of a d-c. armature at every moment is greater than the square of the coil current multiplied by the true or ohmic resistance of the coil; and furthermore, that it is more important to laminate and properly invert the turns of the armature winding in the case of a d-c. generator than it is in the case of an a-c. generator.

As an illustration of the method of calculating the loss factor for a given armature winding, the following example is taken.

The armature considered is that of a six-pole d-c. machine operating at 900 rev. per min. The winding is full pitch, simple lap wound. There are two coils per slot, each consisting of a single turn, and the total number of coils is 216. In the armature slot the conductors are arranged two in width and two in depth. The conductors are solid and rectangular in section. Principal conductor and slot dimensions are as follows:

Conductor width, $\frac{w}{2}$	=	0.405 cm.
Total width of copper in slot, w	=	0.81 cm.
Conductor depth, d	=	1.40 cm.
Slot width, s	=	1.19 cm.

. . . .

The armature copper loss for this machine is more than 50 per cent greater than the value as computed in the time-honored manner. Obviously, the reduction in the extra losses of such a winding by laminating and transposing the conductors would result in a higher rating and efficiency.

The ratio of the heat generated in the embedded portion of the top conductors to that in the embedded portion of the bottom conductors is $2.79 \div 1.18 = 2.36$. This is probably a more important consideration than the loss factor for the entire winding, as it measures the non-uniformity of heat distribution between the conductors. If this winding were used in an a-c. generator the loss factor for the winding at the same fundamental frequency would be 1.22. Notice that, in this case, the extra loss factor for the commutated current is more than double the extra loss factor for the sinusoidal current.

RADIO BILL PROVIDES EQUAL ALLOCATION

The House of Representatives has passed the bill previously passed by the Senate but carrying in addition an amendment which requires the Federal Radio Commission to give "an equal allocation of broadcasting licenses, wave lengths and station power."

Section 4 as now proposed amends the second paragraph of Section 9 of the Radio Act of 1927 so that it reads as follows:

"The licensing authority shall make an allocation to each of the five zones established in section 2 of this act of broadcasting licenses of wave lengths and of station power; and within each zone shall make fair and equitable allocation among the different States including the District of Columbia and the territories and possessions thereof in proportion to population."

The bill now goes to conference with a marked disagreement between the Senate and House in the fundamental principle of radio regulation. Conferees have given assurance that they will take early action on the measure.

Proximity Effect in a Seven-Strand Cable

BY J. E. L. TWEEDDALE[1]

Enrolled Student, A. I. E. E.[1]

THE calculation of the alternating current resistance ratio due to skin effect or proximity effect has been worked out for many shapes and combinations of conductors but often without recourse to experimental results. It is, accordingly, the purpose of this work to check calculations with tests for the type of calculation recently developed, covering the losses in several round wires connected in parallel, of which the arrangement is such that unequal currents flow in the different wires. The experimental results with which the calculated results are to be compared are those presented by A. E. Kennelly and H. A. Affel[2] in 1916 for seven-strand cables. Their work covered radio frequencies up to 100,000 cycles in rather small conductors. The derivations as presented here are applicable to all frequencies and sizes of conductors.

The method of attack is the same as that employed by Dr. H. B. Dwight of the Massachusetts Institute of Technology in the solution of the proximity effect in other arrangements of conductors. The writer wishes to acknowledge the aid and help of Dr. Dwight in the solution of this problem.

In a seven-strand conductor, inequalities of current exist in the separate wires of the conductor. If the return conductor is assumed to be at a distance such that its proximity effect is negligible then we have two unknown currents existing in the seven-strand conductor; *i. e.*, the outer concentric conductors will all carry equal currents I_1 and the center conductor will carry a current I_2 so that the total current $I = 6\,I_1 + I_2$.

The effect of spiraling of the wires has been neglected in this calculation. While the wires of a cable are spiraled, the test with which this calculation is to be compared, illustrated in Figs. 4 and 5, was made on seven straight, unspiraled round wires.

The method of attack is in the main as follows: The current density in a single isolated round wire is given by the following expression:

$$i_{r\theta} = \frac{I_1}{\pi\, a^2}\,\frac{j\,\alpha\, a}{2}\,\frac{J_0\,(j\,\alpha\, r)}{J_1\,(j\,\alpha\, a)} \text{ absamps./sq. cm.} \qquad (1)$$

where r and θ are the polar coordinates of any point in the section of the wire, where

I_1 = total current in the wire

a = radius of the wire

$$\alpha = \sqrt{\frac{j\,\omega\, 4\,\pi}{\sigma}}$$

$\omega = 2\,\pi \times$ frequency

σ = resistivity of material of conductor

and $j = \sqrt{-1}$.

Absolute electromagnetic units are used throughout. The quantity $J_0\,(j\,\alpha\, r)$ is a Bessel function of the first kind, zero order and argument $j\,\alpha\, r$. This can be expressed as an algebraic series but is readily evaluated from tables in which $J_0\,(b\,j\,\sqrt{j}) = u_0 + j\,v_0$, where $j\,\alpha\, r = b\,j\,\sqrt{j}$. The above equation, (1), is based on the fact that the impedance drops at every section of the wire are equal.

The next point is to obtain the effect of the current in the other wires on the distribution of the current in the first wire. It has been shown by Manneback[3] that a current I_2 flowing in an infinitesimal wire will cause a circulating current to flow in a wire of radius a

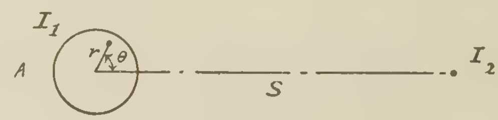

FIG. 1—ROUND WIRE AND INFINITESIMAL WIRE

at an axial distance s whose current density will be

$$i_{r\theta} = \frac{I_2}{\pi\, a^2}\, j\,\alpha\, a \sum_{n=1}^{n=\infty} \frac{a^n}{s^n}\,\frac{J_n\,(j\,\alpha\, r)}{J_{n-1}\,(j\,\alpha\, a)} \cos n\,\theta \qquad (2)$$

J_n represents a Bessel function of the first kind of order n.

The effect of the current distribution given by (2) is that the impedance drops at every section of the wire are equal. The total current in the wire, obtained by adding up expression (2) over the entire section of the wire, is zero. Since the above two conditions are satisfied, the current density given by (2) can be added to that given by (1) without changing the total current I_1. The necessary condition of equal impedance drops at every section of the wire is still met. The sum of (1) and (2) therefore gives the current distribution in a wire carrying current I_1, and with a concentrated current I_2 near it. Other expressions of the same form as (2) may be added for all the other concentrated alternating currents which may be near the wire.

Now, returning to the seven-strand cable we see that

1. Enrolled Student, A. I. E. E., Massachusetts Institute of Technology, Cambridge, Mass.

2. "Skin-Effect Resistance Measurements at Radio Frequencies up to 100,000 Cycles per Second," by A. E. Kennelly and H. A. Affel. Proc. Inst. of Radio Engineers, May, 1916, and *Research Bulletin* No. 13, Mass. Institute of Technology.

Presented at the Regional Meeting of Dist. No. 1, Pittsfield, Mass., May 25-28, 1927.

3. Equation (19), "An Integral Equation for Skin Effect in Parallel Conductors," by Charles Manneback. *Journal of Math. and Physics*, April, 1922, and *Research Bulletin* No. 30, Mass. Institute of Technology.

if we are considering wire A, the proximity effect of the other six conductors must be taken into account. The first step is to assume conductors B, C, D, E, F, and G as infinitesimal conductors. The resultant current density in wire A will be the sum of equation (1) plus the

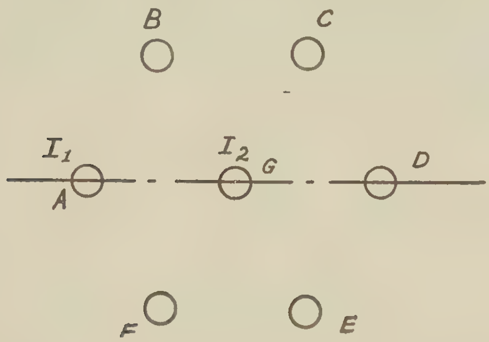

FIG. 2—SEVEN WIRES ARRANGED IN CABLE FORM

respective terms for the other conductors similar in form to equation (2).

The resultant expressions will be, then, as follows:

$$i_{r\theta} = \frac{I_1}{\pi\, a^2} A_0 J_0 (j\,\alpha\, r) + \sum_{n=1}^{n=\infty} A_n J_n (j\,\alpha\, r) \cos n\,\theta \quad (3)$$

and

$$i_{u\gamma} = \frac{I_2}{\pi\, a^2} A_0 J_0 (j\,\alpha\, u) + \sum_{n=1}^{n=\infty} F_n J_n (j\,\alpha\, u) \cos n\,\gamma, \quad (4)$$

etc.,

where A_0, A_n, and F_n are coefficients which for this derivation are as follows:

$$A_0 = \frac{j\,\alpha\, a}{2\, J_1 (j\,\alpha\, a)}. \quad (5)$$

$$A_n = \frac{I_2}{\pi\, a^2} j\,\alpha\, a \frac{a^n}{s^n} \frac{1}{J_{n-1} (j\,\alpha\, a)} + \frac{I_1}{\pi\, a^2} \frac{a^n}{s^n} \frac{j\,\alpha\, a}{J_{n-1} (j\,\alpha\, a)} \left[2 \cos \frac{n\,\pi}{3} + \frac{2}{(\sqrt{3})^n} \cos \frac{n\,\pi}{6} + \frac{1}{(2)^n} \right]. \quad (6)$$

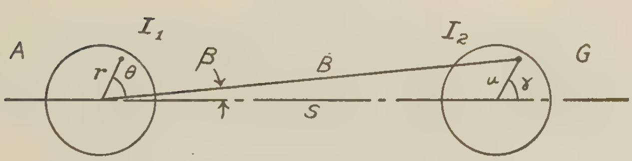

FIG. 3—TWO ROUND WIRES

$$F_n = \frac{I_1}{\pi\, a^2} \frac{a^n}{s^n} \frac{j\,\alpha\, a}{J_{n-1} (j\,\alpha\, a)} \left[\cos n\,\pi + 2 \cos \frac{2\, n\,\pi}{3} + 2 \cos \frac{n\,\pi}{3} + 1 \right]. \quad (7)$$

The expressions (3) and (4) are, therefore, the current densities due to uniform current densities in the others, and I_1 and I_2 in the wires themselves.

The next step is to find the current in each wire due to the A_0 and A_m or F_m currents in the others. For simplicity, let us consider just two of the wires as in Fig. 2, A and G, for the present, to show the method.

Let there be a current density in A in addition to the uniform current density

$$i_{r\theta} = - \frac{I_1}{\pi\, a^2} + \frac{I_1}{\pi\, a^2} A_0 J_0 (j\,\alpha\, r) + \sum_{m=1}^{m=\infty} A_m J_m (j\,\alpha\, r) \cos m\,\theta \quad (8)$$

and likewise for G

$$i_{u\gamma} = - \frac{I_2}{\pi\, a^2} + \frac{I_2}{\pi\, a^2} A_0 J_0 (j\,\alpha\, u) + \sum_{m=1}^{m=\infty} F_m J_m (j\,\alpha\, u) \cos m\,\gamma\,. \quad (9)$$

Each of these integrated over its section will be zero.

Then, the nth term of $i_{r\theta}$ due to $i_{u\gamma}\, u\, du\, d\gamma$ in G is as follows:

$$i_{u\gamma} \frac{j\,\alpha\, a}{\pi\, a^2} \frac{a^n}{B^n} \frac{J_n (j\,\alpha\, r)}{J_{n-1} (j\,\alpha\, a)} \cos n\,(\theta - \beta)\, u\, du\, d\gamma \quad (10)$$

where B and β are variables given by a series for each wire.

$$\frac{\cos n\,\beta}{B^n} = \frac{1}{s^n} \left[1 + \sum_{k=1}^{k=\infty} \frac{\underline{/n + k - 1}}{\underline{/n-1}\;\underline{/k}} \frac{u^k}{s^k} \cos k\,(\gamma - \pi) \right] \quad (11)$$

and

$$\frac{\sin n\,\beta}{B^n} = \frac{1}{s^k} \sum_{k=1}^{k=\infty} \frac{\underline{/n + k - 1}}{\underline{/n-1}\;\underline{/k}} \frac{u^k}{s^k} \sin k\,(\pi - \gamma)\,. \quad (12)$$

The proof of the two preceding expressions is given by H. L. Curtis.[4]

Substituting expression (9) in (10), expanding the difference of the angles, and substituting their respective values from (11) and (12), the nth term of $i_{r\theta}$

$$\left[- \frac{I_2}{\pi\, a^2} + \frac{I_2}{\pi\, a^2} A_0 J_0 (j\,\alpha\, u) + \sum_{m=1}^{m=\infty} F_m J_m (j\,\alpha\, u) \cos m\,\gamma \right]$$

4. H. L. Curtis, Scientific Paper No. 374 of the Bureau of Standards, Washington, D. C., 1920.

$$\left[\frac{j\,\alpha\,a}{\pi\,a^2}\,\frac{a^n}{s^n}\,\frac{J_n\,(j\,\alpha\,r)}{J_{n-1}\,(j\,\alpha\,a)}\right]\left\{\cos n\,\theta\left[1 + \sum_{k=1}^{k=\infty}\frac{\lfloor n+k-1}{\lfloor n-1\,\lfloor k}\,\frac{u^k}{s^k}\cos k\,(\gamma-\pi)\right]\right.$$

$$+\sin n\,\theta\left[\sum_{k=1}^{k=\infty}\frac{\lfloor n+k-1}{\lfloor n-1\,\lfloor k}\,\frac{u^k}{s^k}\right.$$

$$\left.\left.\sin k\,(\pi-\gamma)\right]\right\}u\,du\,d\gamma. \qquad (13)$$

The above expression is then integrated between the limits 0 to $2\,\pi$ and 0 to a. The sine term will become zero upon integration and drop out, and likewise

$$\int_0^a\left[-\frac{I_2}{\pi\,a^2}+\frac{I_2}{\pi\,a^2}\,A_0\,J_0\,(j\,\alpha\,u)\right]u\,du = 0.$$

Thus there is left the integral of the nth term of the terms in m which is

$$\sum_{m=1}^{m=\infty}\frac{a^{m+n}}{s^{m+n}}\,\frac{J_{m+1}\,(j\,\alpha\,a)}{J_{n-1}\,(j\,\alpha\,a)}\left[\frac{\lfloor n+m-1}{\lfloor n-1\,\lfloor m}\right]$$

$$[F_m\cos m\,\pi]\,J_n\,(j\,\alpha\,r)\cos n\,\theta\,. \qquad (15)$$

Let B_n be the coefficient of $J_n\,(j\,\alpha\,r)\cos n\,\theta$.

Now let there be an additional current density in A as represented by the expression (**15**). The resulting current in A due to this additional current is given by

$$C_n\,J_n\,(j\,\alpha\,r)\cos n\,\theta \qquad (16)$$

where C_n is given by the formula for B_n except change A to B and F to G.

This process may be continued indefinitely, approaching the final limiting condition of the actual current density. The final current density in the two wires will be as follows:

$$i_{r\theta} = \frac{I_1}{\pi\,a^2}\,A_0\,J_0\,(j\,\alpha\,r) + \sum_{n=1}^{n=\infty}M_n\,J_n\,(j\,\alpha\,r)\cos n\,\theta \qquad (17)$$

and for conductor G

$$i_{u\gamma} = \frac{I_2}{\pi\,a^2}\,A_0\,J_0\,(j\,\alpha\,u) + \sum_{n=1}^{n=\infty}N_n\,J_n\,(j\,\alpha\,u)\cos n\,\gamma \qquad (18)$$

where $\quad M_n = A_n + B_n + C_n + \ldots \qquad (19)$

and $\quad N_n = F_n + G_n + H_n + \ldots \qquad (20)$

Thus far, only conductors A and G have been considered for simplicity. For the seven-strand problem, the effect of conductors B, C, D, E, and F may be determined by the introduction of their respective terms in the preliminary equations. The introduction of these terms will not affect the general form of the final equations for the current density as given in (**17**) and (**18**) but will affect the coefficients A_n, B_n, C_n, etc., and F_n, G_n, H_n, etc., which are dependent on the unknown currents I_1 and I_2 and on the geometry and dimensions of the circuit.

Thus, for the seven strand problem the coefficients are as follows:

$$A_0 = \frac{j\,\alpha\,a}{2\,J_1\,(j\,\alpha\,a)}\,. \qquad (21)$$

$$A_n = \frac{I_2}{\pi\,a^2}\,\frac{a^n}{s^n}\,\frac{j\,\alpha\,a}{J_{n-1}\,(j\,\alpha\,a)} + \frac{I_1}{\pi\,a^2}\,\frac{a^n}{s^n}\,\frac{j\,\alpha\,a}{J_{n-1}\,(j\,\alpha\,a)}\left[2\cos\frac{n\,\pi}{3} + \frac{2}{(\sqrt{3})^n}\cos\frac{n\,\pi}{6} + \frac{1}{(2)^n}\right]. \qquad (22)$$

$$B_n = \sum_{m=1}^{m=\infty}\frac{a^{m+n}}{s^{m+n}}\,\frac{J_{m-1}\,(j\,\alpha\,a)}{J_{n-1}\,(j\,\alpha\,a)}\left[\frac{\lfloor n+m-1}{\lfloor n-1\,\lfloor m}\right]\times$$

$$\left[F_m\cos m\,\pi + 2\,A_m\cos\frac{\pi\,(m-n)}{3} + \frac{2\,A_m}{(\sqrt{3})^{m+n}}\cos\frac{\pi\,(m-n)}{6} + \frac{A_m}{(2)^{m+n}}\right]. \qquad (23)$$

C_n is given by the same expression as B_n except change A to B and F to G, likewise for any subsequent terms.

$$F_n = \frac{I_1}{\pi\,a^2}\,\frac{a^n}{s^n}\,\frac{j\,\alpha\,a}{J_{n-1}\,(j\,\alpha\,a)}\left[\cos n\,\pi + 2\cos\frac{2\,n\,\pi}{3} + 2\cos\frac{n\,\pi}{3} + 1\right]. \qquad (24)$$

$$G_n = \sum_{m=1}^{m=\infty}A_m\,\frac{a^{m+n}}{s^{m+n}}\,\frac{J_{m+1}\,(j\,\alpha\,a)}{J_{n-1}\,(j\,\alpha\,a)}$$

$$\left[\cos n\,\pi + 2\cos\frac{2\,n\,\pi}{3} + 2\cos\frac{n\,\pi}{3} + 1\right]$$

$$\frac{\lfloor n+m-1}{\lfloor n-1\,\lfloor m}\,. \qquad (25)$$

H_n is given by the same expression as G_n except change A to B; likewise for any subsequent terms. For all terms except the sixth or multiples of the sixth, F_n, G_n, etc., will be zero.

As said before the expressions for the current density will be as given in (**17**) and (**18**) with the use of the above coefficients. The expressions for the current density in the other conductors, B, C, D, E, and F, will be similar to (**17**) except for the use of their respective polar coordinates.

There are now two unknown currents I_1 and I_2.

Their ratio may be determined, since the conductors of the cable are in parallel, by finding the voltage drop in each wire in terms of I_1 and I_2. Then, the voltage drops in any two parallel filaments are equal and can be equated, giving the ratio of I_1/I_2.

The simplest expression to derive is that for the drop in the central filament of the wire. This, then, is equal to the drop in any other filament. In wire A the resistance drop in the central filament is $i_0\,\sigma$ where i_0 is the current density at the center. Using equation (17) this is

$$\frac{I_1}{\pi a^2} A_0\,\sigma = \frac{I_1\,\sigma}{\pi a^2}\;\frac{j\,\alpha\,a}{2\,J_1(j\,\alpha\,a)} \tag{26}$$

since $J_0(0) = 1$ and $J_n(0) = 0$ where $n \neq 0$.

The reactive drop in the central filament due to the element of current $i_{r\theta}\,r\,d\,\theta\,d\,r$ is

$$j\,\omega\,2\,i_{r\theta}\left(\operatorname{logh}\frac{p}{r}\right) r\,d\,\theta\,d\,r \tag{27}$$

$$= j\,\omega\,2\,\frac{I_1}{\pi\,a^2}\frac{j\,\alpha\,a}{2}\frac{J_0(j\,\alpha\,r)}{J_1(j\,\alpha\,a)}\left(\operatorname{logh}\frac{p}{r}\right) r\,d\,\theta\,d\,r$$

$$+ j\,\omega\,2\sum_{n=1}^{n=\infty} M_n\,J_n(j\,\alpha\,r)\cos n\,\theta\left(\operatorname{logh}\frac{p}{r}\right) r\,d\,\theta\,d\,r. \tag{28}$$

This takes into account the flux up to a certain large distance p. The expression logh denotes the hyperbolic or natural logarithm. Equation (28) was obtained by the use of equation (17). To find the reactive drop due to the entire current I_1, the above expression is integrated from $\theta = 0$ to $2\,\pi$ and $r = 0$ to a. The integral of the second term of (28) will be zero since $\int_0^{2\pi} \cos n\theta\, d\theta = 0$. That of the first term integrating by parts, remembering that $\alpha^2 = \frac{j\,\omega\,4\,\pi}{\sigma}$ is

$$\frac{I_1\,\sigma}{\pi\,a^2}\;\frac{j\,\alpha\,a}{2}\;\frac{J_0(j\,\alpha\,a)}{J_1(j\,\alpha\,a)} + j\,\omega\,2\,I_1\operatorname{logh}\frac{p}{a}$$

$$- \frac{I_1\,\sigma}{\pi\,a^2}\;\frac{j\,\alpha\,a}{2\,J_1(j\,\alpha\,a)}\,. \tag{29}$$

Then the impedance drop at the center of the wire A due to I_1 is the sum of equations (26) and (29) and is

$$\frac{I_1\,\sigma}{\pi\,a^2} A_0\,J_0(j\,\alpha\,a) + j\,\omega\,2\,I_1\operatorname{logh}\frac{p}{a}\,. \tag{30}$$

The reactance drop at the same central filament in A due to currents expressed in the same form as in equations (17) and (18) in the other conductors may be added on.

Similarly, the impedance drop in the central filament of conductor G carrying current I_2 may be found. Since the two wires are in parallel, the impedance drops must be the same. The two equations may then be equated and the ratio of I_1 to I_2 determined.

For the case of the seven strand conductor the impedance drops in conductors A and G are as follows:

$$E_a = \frac{I_1\,\sigma}{\pi\,a^2} A_0\,J_0(j\,\alpha\,a) + j\,\omega\,2\,I_2\operatorname{logh}\frac{p}{s}$$

$$+ j\,\omega\,2\,I_1\operatorname{logh}\frac{p^6}{6\,a\,s^5}$$

$$+ j\,\omega\,2\sum_{n=1}^{n=\infty} N_n\,\pi\,a^2\cos n\,\pi\,\frac{a^n}{n\;s^n}\;\frac{J_{n+1}(j\,\alpha\,a)}{j\,\alpha\,a}$$

$$+ j\,\omega\,2\,\pi\,a^2\sum_{n=1}^{n=\infty} M_n\,\frac{J_{n+1}(j\,\alpha\,a)}{j\,\alpha\,a}\;\frac{a^n}{n\;s^n}\times$$

$$\left[2\cos\frac{n\,\pi}{3} + \frac{2}{(\sqrt{3})^n}\cos\frac{n\,\pi}{6} + \frac{1}{(2)^n}\right]. \tag{31}$$

and

$$E_g = \frac{I_2\,\sigma}{\pi\,a^2} A_0\,J_0(j\,\alpha\,a) + j\,\omega\,2\,I_2\operatorname{logh}\frac{p}{a}$$

$$+ j\,\omega\,12\,I_1\operatorname{logh}\frac{p}{s}$$

$$+ j\,\omega\,12\sum_{n=1}^{n=\infty} M_n\,\pi\,a^2\,\frac{a^n}{n\;s^n}\;\frac{J_{n+1}(j\,\alpha\,a)}{j\,\alpha\,a}\,. \tag{32}$$

It is to be noted again that M_n and N_n are expressions involving the unknown currents I_1 and I_2 as well as the geometry of the circuit.

For the determination of the watts loss and the resistance ratio, the process is as follows:

Let $$e_{r\theta} = \sigma\,i_{r\theta}\,. \tag{33}$$

Then by equation (10) of J. R. Carson's paper,[5]

$$j\,\mu\,\omega\,H_{r\theta} = \frac{\partial}{\partial\,r}\,e_{r\theta} \tag{34}$$

where μ is the permeability and, for this case, equal to 1. $H_{r\theta}$ is the tangential component of the magnetic force due to the currents in the wires.

Then

$$j\,\omega\,H_{r\theta} = \frac{I_1\,\sigma}{\pi\,a^2} A_0\,j\,\alpha\,J_0'(j\,\alpha\,r)$$

$$+ \sum_{n=1}^{n=\infty} \sigma\,M_n\,j\,\alpha\,J_n'(j\,\alpha\,r)\cos n\,\theta. \tag{35}$$

By equation (18) of Carson's paper, the true energy

5. "Wave Propagation over Parallel Wires: The Proximity Effect," by J. R. Carson, *Philosophical Mag.*, April, 1921, page 607.

transferred to or from one centimeter of wire through its surface, according to Poynting's theory, is equal to the resistance loss and is

$$\hat{I}\, I\, R' = \text{real part of } \frac{a}{4\,\pi} \int_{\theta=0}^{\theta=2\pi} \hat{e}_{a\theta}\, H_{a\theta}\, d\,\theta. \qquad (36)$$

This it is noticed involves only values at the surface of the wire, so the integration is not complicated. The term $\hat{e}_{a\theta}$ is the conjugate of $e_{a\theta}$, taken at the surface, and is obtained by replacing j by $-j$.

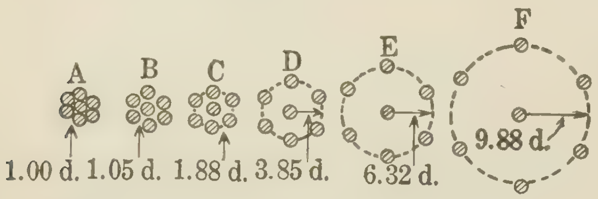

FIG. 4—WIRE SPACING. (KENNELLY AND AFFEL, REFERENCE 1)

Then the loss in conductor A is

$$\frac{b}{2}\left[\hat{I}_1\, I_1\, \frac{\sigma}{\pi\, a^2}\, \frac{(u_0\, v_0' - u_0'\, v_0)}{(u_0'^2 + v_0'^2)}\right.$$

$$\left. + \sum_{n=1}^{n=\infty} \frac{b\,\sigma^2}{4\,\omega}\, \hat{M}_n\, M_n\, (u_n\, v_n' - u_n'\, v_n)\right] \qquad (37)$$

and the loss in conductor G is

$$\frac{b}{2}\left[\hat{I}_2\, I_2\, \frac{\sigma}{\pi\, a^2}\, \frac{(u_0\, v_0' - u_0'\, v_0)}{(u_0'^2 + v_0'^2)}\right.$$

$$\left. + \sum_{n=1}^{n=\infty} \frac{b\,\sigma^2}{4\,\omega}\, \hat{N}_n\, N_n\, (u_n\, v_n' - u_n'\, v_n)\right]. \qquad (38)$$

It is to be noticed that

$$\hat{M}_n\, M_n = |M_n|^2 \text{ and } \hat{I}_1\, I_1 = |I_1|^2, \text{ etc.}$$

The loss in any one wire at zero frequency is given

$$= \frac{I^2}{49}\, \frac{\sigma}{\pi\, a^2}. \qquad (39)$$

Then by determination of the loss by equations (37) and (38) and the loss for the same conditions at zero frequency by (39) the ratio of losses will give the resistance ratio for conductors A and G and thence the average resistance ratio of the cable may be determined.

RESULTS

The expressions having been derived, two calculations were made using tables of $J_n\,(b\, j\, \sqrt{j})$ as calculated by H. B. Dwight.[6] A value of $b = 2$ was chosen which for the size of wire corresponds to a frequency of 88,300 cycles/second. Calculations for two spacings, $s/a = 2$ and $s/a = 3.76$ corresponding to curves A and C of Fig. 5, were made.

The calculated results as compared with the corresponding results of Fig. 5 for these spacings are as follows:

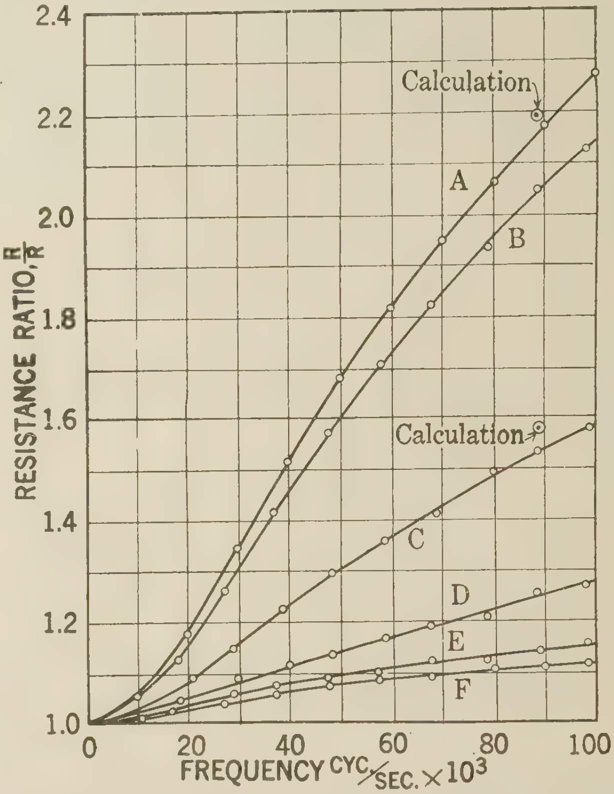

FIG. 5—EFFECT OF STRAND SPACING ON THE SKIN EFFECT OF A STRANDED CONDUCTOR. (KENNELLY AND AFFEL, REFERENCE 1)

	$s/a = 2$	$s/a = 3.76$
Calculated	2.19	1.58
Figure 5 (test)	2.15	1.53

The resistance ratio for an equivalent single round conductor for the same conditions is 2.1457.

6. *Proximity Effect in Wires and Thin Tubes*, by H. B. Dwight, TRANS. A. I. E. E., 1923, page 858.

ILLUMINATION ITEMS

By Committee on Production and Application of Light

PRESENT STATUS OF AERONAUTICAL LIGHTING IN U. S.*

The paper discusses aeronautical lighting under four principal heads; namely, airways, intermediate field, airports, and airplanes. It describes and illustrates equipment in considerable detail which will be but briefly mentioned herein.

*A paper presented before the Annual Convention of the Illuminating Engineering Society, Chicago, Ill., October 11-14, 1927. *Transactions of I. E. S.*, November 1927.

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Airways. The main standard beacon used for marking the course on new airways consists of a 24-in. silvered glass parabolic mirror projector which rotates its vertical axis at 6 rev. per min. These projectors are spaced from 10 to 20 mi. apart. In this beacon, a special 1000-watt incandescent lamp is employed. Such a unit will produce a beam of about 2,000,000 candlepower with a 4½-deg. spread. The beam is elevated 2 deg. above horizontal. To increase the reliability of performance of unattended beacons, devices which will automatically replace a lamp which fails with a new one are provided.

Small beacons used to mark important details in the course may be of a flashing acetylene type which operate for 6 months without attention.

At crossings or branches in the air-routes, special markers are employed. They can be flashed by turning the lamp on and off, and the flashing can be made distinctive by coding.

The newer beacons are being supplied with two "on-course" lights having a beam spread of about 40 deg.

Intermediate Fields. The general present practise in laying out an airway is to locate every third or fourth beacon adjacent to an intermediate landing field, which must have the following lighting equipment in addition to the beacon; (1) boundary lights; (2) wind cone illumination; (3) obstruction lights; (4) floodlights for airway direction arrow.

Boundary lights usually consist of 15- or 25-watt lamps spaced 200 or 300 ft. apart along the boundary of the field. The wind cone is illuminated by a floodlight or by a lamp placed in the mouth of the cone. Floodlights illuminate the big direction arrow at the base of the beacon and the route number.

Obstruction lights must be provided on all objects over 100 ft. high near an airway, field or airport. Any object that projects above a gliding angle of 7 to 1 from the edge of a field should be marked. Where such an obstacle as a transmission line crosses an airway, it is advisable to place obstruction lights on the towers for at least 1½ miles either side of the center line of the airway.

Airports. A modern airport employs the following lighting equipment:

A beacon to guide the pilot to the airport.

Boundary, approach and obstruction lights for indicating the extent of the field, the best approaches, and obstructions to landing.

Hangar lights to give perspective.

Wind indicator lights to show wind direction.

Floodlighting to assure a safe landing.

A ceiling light to indicate cloud or fog height.

In addition to the standard beacon, a stationary one employing 1000- or 1500-watt lamps giving coding flashes are often used for identification.

Neon beacons have been installed at several airports in this country for experimental observation to determine particularly their visibility under adverse weather conditions.

Boundary, approach, and obstruction lights are in general similar to those used for intermediate fields. They may be either of the series or multiple type. Favorable points of approach to the field are usually marked with one or two green lights on the border.

The exterior of each hangar is floodlighted.

There are two accepted systems of floodlighting a field or runway for night landing, which may be classified as follows:

Centralized system consisting of one or more light sources assembled at one point.

Distributed system consisting of one or more sources spaced several hundred feet apart along the borders of runways.

Several types of equipment for the centralized system are available. One type employs a hand-ground Fresnel lens approximately 3 ft. high and 3 ft. in diameter. This gives a fan of light with a 1½- to 2-deg. vertical spread through a horizontal angle of 140 deg. parallel to the ground and with a very sharp cut off. Another type consists of a high-intensity arc in a 18-in. parabolic mirror. A 36-in. parabolic mirror with 10-kw. incandescent lamps has also been used. Another unit is a twin floodlight employing two 5-kw. or two 10-kw. incandescent lamps in 24-in. parabolic mirrors. Plates are provided to give the beams a horizontal spread covering altogether 80 deg. Stray upward light is cut off by louvers. Several such units may be mounted to cover an angle of 180 deg.

The distributed system of field illumination ordinarily employs smaller units installed along the boundaries of the field. On wavy or uneven ground this system produces an illumination quite free from shadows. Such lighting may be obtained by a number of 24-in. parabolic reflectors spaced about 250 ft. apart around the edge of the field. Where economy is necessary, units may be provided only on two sides of the area, the rows being grouped according to the prevailing winds. Another type of unit for distributed lighting employs a small Fresnel lens.

Airplanes. One of the essential departments of lighting necessary for night flying is the illumination equipment on the airplane itself. The airplane should have illumination for the following purposes:

1. Running lights, similar in general to the marine running lights.

2. Landing lights for use in emergency landing.

3. Signal lights for signaling airports or landing field.

Of course, there will be instrument board illumination and cock-pit or cabin illumination, but these are not considered in this paper.

Baltimore Regional Meeting April 17-20

An excellent program is arranged for the Regional Meeting which will be held in Baltimore, April 17-20, under auspices of the Middle Eastern District. The Hotel Belvedere will be headquarters for the meeting. The program will be as published in the March Journal, page 218, except that the paper *Behavior of Dielectrics* announced for the afternoon session on April 17 will not be presented. Also, contrary to the former announcement, this session will be held in the Civil Engineering Building of Johns Hopkins University. All other sessions will be at the Hotel Belvedere.

Technical Program

As announced, the technical papers will be devoted to the general subjects of dielectrics and power generation. Three papers will be presented on dielectrics and insulation. Another group will cover the Gould Street Generating Station of the Consolidated Gas, Electric Light and Power Company Two other sessions will be devoted to the Conowingo development of the Philadelphia Electric Company, covering such features as design, 220-kv. transmission, quick-response excitation, stability and communication.

Hotel Reservations

Reservations for hotel accomodations should be sent to R. T. Greer, chairman of the Hotel Committee, in care of the Consolidated Gas, Electric Light and Power Company, Madison Street Building, Baltimore, Md. As the hotels in Baltimore will be crowded at this time, all visitors may not be able to get rooms at the Belvedere, but the Hotel Committee will make reservations elsewhere if necessary. The hotel rates are as follows:

	Room Rates per Day (with private bath)
Room with double bed	One person \$5-6 Two persons \$7-8
Room with twin beds	\$8, \$10, \$12

Reduced Railroad Fares

Special railroad rates will be available to out-of-town visitors under the certificate plan providing 250 certificates are registered at the convention. Each person attending the convention should request a certificate when purchasing a one-way ticket to Baltimore. Presentation of this certificate at the convention headquarters will entitle the holder to a half-rate fare for the return trip over the same route.

When purchasing tickets, members or guests should advise the ticket agent that they are attending the A. I. E. E. Regional convention in Baltimore and should ask for certificates. Families of members attending the convention are also entitled to certificates.

Everyone should obtain a certificate whether or not he will use it, for failure to do so may deprive others coming long distances of the saving in railroad fare made possible by this provision.

Regional Meeting at New Haven May 9-12, 1928

The 5th annual meeting of the Northeastern District will be held at New Haven, Connecticut, on May 9-12. Headquarters will be at the Hotel Taft and the Connecticut Section will act as host. Technical papers of unusual interest, inspection trips, a Branch conference and entertainment make up the well rounded program.

New Haven is easily accessible by excellent train service, fine state roads, and motor bus service. Settled in 1638, it has many points of historical interest; while the modern Yale with its many traditions, its architecturally famous buildings, its Engineering School and laboratories never fails to interest the visitor.

Technical Sessions

Four technical sessions will be held. The first will be a joint symposium arranged by the Committees on Instruments and Measurements and on Protective Devices, dealing with the instruments available for the study and measurement of system disturbances, and the application of protective devices to control their effects on system operation.

A major part of the technical program has been devoted to four unique engineering developments in the vicinity. These include a hydroelectric project, electric railway power from rectifiers, variable-ratio frequency changers, and mercury turbines.

A paper will be presented on the exclusive use of mercury arc rectifiers for supplying power to a trolley system, and a second paper, on inductive coordination between the railway feeder system and local communication circuits where these rectifiers are in use.

The economics of power supply for railway electrification will be covered by another paper.

Two very interesting papers will deal with 25-cycle power obtained through two variable-ratio frequency-changer sets, one deriving power from another 25-cycle source, and the second, power from a utility system at 60 cycles.

A hydroelectric development of unusual interest, in which the excess water will be pumped into a storage basin, is the subject of another paper. This water will be pumped on some occasions by a portion of the excess water power and on other occasions by steam power from other points on the system.

A paper on the mercury boiler and turbine will be another of this group on unique developments.

Special consideration will be given to "Initial Papers" and the Friday morning session is reserved for papers by Student Branch members. The accompanying program gives detailed information on all the technical papers.

Inspection Trips

The inspection trips have been coordinated with the technical papers, so that the four unusual developments in the field of hydroelectric plants, railway and street railway power and mercury turbines, may be visited. Visitors will also be able to inspect the latest types of locomotives as now used by the New Haven Road, including the new 1000-hp. 3-cylinder, high-speed electric controlled steam freight type, the motor-generator electric freight type, the d-c/a-c. single-phase passenger type, the a-c. freight type and the gas-electric rail car.

Registration for these inspection trips should be made at the registration desk as soon as possible after arrival in order to allow the committee ample time to complete arrangements.

Entertainment

On Wednesday evening, May 9, there will be an informal reception with music and dancing or cards, as one desires.

On Thursday evening an informal banquet will be given for members and lady guests.

On Friday evening the Yale University Department of Drama will give a complimentary performance at the University Theater. Guides will be available for those desiring to inspect the University buildings.

A ladies' committee has been appointed to provide entertainment for the visiting ladies during the technical sessions and will include bridge parties, teas, and automobile drives along the Connecticut Shore. A schedule of the events for the ladies is published below.

Three excellent golf courses, (including the famous Yale course), and tennis courts are available for those attending the convention. A golf tournament will be held the first two days of the

convention for which the committee announces prizes for the winners. The Yale gymnasium and its swimming pool will be open to convention visitors.

Registration

Members are requested to register in advance as far as possible by writing to C. J. Daly, The Southern New England Telephone Company, New Haven, Connecticut. In order to cover part of the necessary expense incidental to the convention, a nominal registration fee of $1.00 will be collected from the men at the meeting.

Hotel Accomodations

Meeting headquarters will be at the Hotel Taft. Rates, etc., are given below. Advance reservations should be made directly with the hotel at as early a date as possible.

HOTEL RATES

	Single Rooms		Double Rooms	
	Without Bath	With Bath	Without Bath	With Bath
*Hotel Taft	$4.25	$4.75* 5.00*	$7.50* 8.00*	$9.00* 10.00*
(Three or more sharing large room with bath and separate beds—rate per person $4.00)				
Hotel Duncan	$2.00	$3.00	$3.50 4.00	$5.00 6.00
Hotel Garde	2.50	3.50	5.00	6.00
Hotel Strand	1.50 2.00	3.00	3.50 4.00	5.00

*Note: Hotel Taft rates include breakfast.

Committees

The general committee in charge of the meeting is as follows: H. M. Hobart, Chairman, Vice-President in Northeastern District; A. C. Stevens, Secretary; W. H. Colburn, L. E. Imlay, C. A. M. Weber, W. H. Timbie, F. M. Sebast, R. F. Chamberlain, A. E. Knowlton, and R. G. Warner.

The chairmen of the other committees are as follows: Local Executive Committee, A. E. Knowlton; Hotels and Registration, C. J. Daly; Inspection Trips, E. J. Amberg; Publicity, C. H. Clements; Transportation, H. F. Brown; Ladies Entertainment, Mrs. E. H. Everit; Entertainment and Banquet, F. L. Ferguson; Sports, S. K. Wolf.

PROGRAM

(Daylight Saving Time)

All technical sessions at Hotel Taft Ballroom, except Wednesday afternoon continuation of symposium.

Wednesday, May 9

9:00 a. m. Registration
10:00 a. m. Address of Welcome, H. M. Hobart, Vice-President, Northeastern Dist. A. I. E. E.
10:15 a. m. Technical Session, R. T. Pierce, Chairman

SYMPOSIUM ON SURGE MEASUREMENTS AND PROTECTIVE DEVICES

Application of Relays for Protection of Power-System Interconnections, L. N. Crichton and H. C. Graves, Westinghouse Elec. & Mfg. Co.

Application of Wound-Type Current Transformers to High-Voltage Circuit Breakers, J. C. Rea, Pacific Electric Mfg. Co.

Relation Between Transmission-Line and Transformer Insulation, W. W. Lewis, General Electric Co.

Rationalization of Transmission-System Insulation Strength, Philip Sporn, American Gas and Electric Co.

Hall High-Speed Recorder, C. I. Hall, General Electric Co.

Pages from the Hall High-Speed Recorder, E. M. Tingley, Commonwealth Edison Co.

Oscillograph Recording of Transmission-Line Disturbances, J. W. Legg, Westinghouse Electric & Mfg. Co.

High-Speed Graphic Voltmeter, A. F. Hamdi and H. D. Braley, New York Edison Co.

(This symposium will be continued at 2:00 p. m. in Dunham Laboratory, 10 Hillhouse Ave., with F. L. Hunt, Chairman.)

2:00 p. m. Technical Session, Harold B. Smith, Chairman

MISCELLANEOUS PAPERS

Selection of Railway Motor Equipment by Principles of Similar Speed-Time Curves, B. A. Widell, General Electric Co.

Shunting of Track Circuit in Polyphase Continuous Inductive Train Control, C. F. Estwick, General Railway Signal Co.

The Diverter-Pole Generator, E. D. Smith, Jr., Rochester Electric Products Corp.

Electric Conduction in Hard Rubber, Pyrex, Glass, Fused and Crystalline Quartz, H. H. Race, Cornell University

3:00 p. m. Inspection trip, electric motive power equipment, N. Y., N. H. & H. R. R.
8:30 p. m. Informal reception, Hotel Taft. Music, dancing, cards.

Thursday, May 10

9:00 a. m. Technical Session, Sidney Withington, Chairman

RAILROAD AND RAILWAY POWER

Interconnection of Power and Railway Traction System by Means of Frequency Changers, L. Encke, N. Y., N. H. & H. Railroad

Application of Large Frequency Changers to Power Systems, E. J. Burnham, General Electric Co.

Electrification on Illinois Central R. R., R. F. Schuchardt, Commonwealth Edison Co. and W. M. Vandersluis, Illinois Central R. R.

Mercury Arc Rectifier Substations, G. E. Wood, The Connecticut Co.

Effect of Street Railway Mercury Arc Rectifiers on Communication Circuits, C. J. Daly, Southern New England Telephone Co.

2:00 p. m. Inspection trips.
1. Mercury arc rectifier substations, The Connecticut Company (Bridgeport)
2. Frequency-converter substations, The Connecticut Company (New Haven), The Conn. Light & Power Co. (Devon)

7:00 p. m. Banquet

Friday, May 11

8:30 a. m. Inspection Trip (Hartford)
Mercury boiler and turbine, Hartford Electric Light Co.
Hartford Hump Yard, Electric Braking N. Y., N. H., & H. R. R. Co.
9:00 a. m. Symposium on Student Branch Activities
10:30 a. m. Student technical session
12:30 p. m. Branch conference luncheon
2:00 p. m. Technical session, William S. Gorsuch, Chairman

POWER DEVELOPMENTS

(The lectures at this session will be illustrated with charts and slides and will include material not incorporated in the printed papers.)

The Mercury Boiler and Turbine, L. A. Sheldon, General Electric Co.

The Rocky River Development of the Connecticut Light and Power Co., E. J. Amberg, Connecticut Light and Power Co.

4:30 p. m. Inspection Tour, Yale University
8:00 p. m. Theater Party, Courtesy of The Dept. of Drama, School of Fine Arts, Yale University

Saturday, May 12

9:00 a. m. Inspection Trip (New Milford)

ROCKY RIVER HYDROELECTRIC DEVELOPMENT

Connecticut Light and Power Company

At Rocky River, on the Housatonic, this hydroelectric development is nearing completion. It is the first development in the U. S. where flood water is to be pumped to an elevated

storage reservoir. The result will be a complete economic utilization of the entire river below this point.

LADIES' ENTERTAINMENT PROGRAM

WEDNESDAY, MAY 9

9:00 a. m. Registration
11:00 a. m. Visit to Memorial Quadrangle and Old Campus, Yale University
3:00 p. m. Auto drive to West Rock Park and Judges Cave. Tea at Giant Valley Country Club
8:30 p. m. Informal Reception. Dancing and Cards

THURSDAY, MAY 10

10:00 a. m. Visit to the gallery of the Yale School of Fine Arts
11:30 a. m. Visit to the Rebecca Darlington Stoddard Collection of Greek and Italian Vases, the Collection of Autograph Letters and Engravings of Eminent Yale Men, and the Steinert Collection of Musical Instruments
3:00 p. m. West Shore Drive. Tea at Race Brook Country Club
7:00 p. m. Convention Dinner

FRIDAY, MAY 11

9:30 a. m. East Shore Drive to Guilford, visiting "Old Stone House" "Whitfield House" and other places of interest
3:00 p. m. Visit to the Collection of Babylonian Antiquities and the Peabody Museum. Tea at the Nathan Hale Inn
8:00 p. m. Theatre Party. Courtesy of Department of Drama, School of Fine Arts, Yale University

SATURDAY, MAY 12

9:00 a. m. Auto drive and inspection trip to the Rocky River Hydroelectric Development, New Milford, Conn.

Summer Convention, Denver June 25-29

Arrangements are being completed for the 1928 annual Summer Convention which will be held in Denver, Colorado, June 25-29, with headquarters at the Cosmopolitan Hotel.

A well rounded technical program is being planned, which will include papers on such subjects as transmission-line surge investigation; operation of electrical machines at high altitudes; feeder control for electrical railways; carrier-current communication; engineering education; geophysics; etc. Reviews of the year in the various lines of electricity will be presented in the reports of the Institute's technical committees.

A conference of Section Delegates will be held under auspices of the Sections Committee.

The local committee is planning some very enjoyable entertainment and sightseeing trips.

A tour to Yellowstone Park and other points is being arranged to follow the conventions, as announced elsewhere in this issue.

Further details of the program will be published in the May and June issues of the JOURNAL.

Institute Tour to Yellowstone Park

A tour of Yellowstone National Park, by way of Colorado Springs and Salt Lake City is being planned for Institute members and guests in connection with the 1928 Summer Convention to be held in Denver, Colorado, June 25-29.

With New York City as a starting point, the entire trip will be made in about eighteen days, including, the time spent in Denver at the Convention. The time required from other points will depend, of course, upon their location. The start will be made from New York on the afternoon of June 22 and the return to New York will be on July 10.

Members from other sections of the country may meet the party at any point along the route including Denver.

The party will arrive at Denver on Sunday evening, June 24, and after the Convention is over, will leave Friday evening, June 29, for Colorado Springs, where they will stay at the Broadmoor Hotel.

At Colorado Springs June 30, Pike's Peak, the Garden of the Gods, South Cheyenne Canyon, and Seven Falls will be visited. Enroute from Colorado Springs on July 1 will be seen the famous Royal Gorge.

Arriving in Salt Lake City on the morning of July 2, trips will be made morning and afternoon, and at noon the organ recital in the Mormon Temple will be heard. Among the trips which can be taken are those to Saltair Beach, the Bingham Copper Mines, and the canyons near the city.

ROUNDING THE SUMMIT OF PIKE'S PEAK

Leaving Salt Lake City on the evening of July 2, the party will arrive at the West Yellowstone entrance on the next morning.

In Yellowstone National Park, four and one-half days will be spent enjoying the many wonders of nature which are there. Old Faithful and many other geysers, Yellowstone Lake, the Grand Canyon and Great Falls of the Yellowstone, Mammoth Hot Springs, Shoshone Lake and Dam are the prominent points that will be visited.

IN THE MONTANA ROCKIES

Leaving the park by way of the Cody road the party will take the train at Cody on the evening of July 7 and will arrive in Chicago July 9 and in New York, July 10.

A most enjoyable feature of this trip will be that all arrangements for railroad and pullman tickets, hotels, automobile tours, baggage transfer, etc., will be made by the travel bureau which has been authorized for the trip.

The cost of the tour, depending on pullman accommodations desired, will be as follows, with New York as the starting point. Rates from other points will differ according to the location.

COST OF TOUR STARTING AT NEW YORK

One in upper berth	One in lower berth	Two in compartment (each person)	Two in drawing room (each person)	Three in drawing room (each person)
$350	$375	$398	$439	$393

. The tour is arranged on the all-expense plan and the cost includes round-trip railroad and pullman transportation, side trips, accommodations at first class hotels (rooms with bath, twin beds) including the Cosmopolitan Hotel, the headquarters of the meeting, all meals (except at Denver), transfer of passengers and baggage, sight-seeing and touring cars, in fact all necessary expenses except meals at Denver, trips in Salt Lake City and tips.

The cost does not include private baths at Yellowstone Park. Such accommodations are limited, but private bath accommodations will be secured for members of the party who desire them there, at slight additional cost.

All who are interested in this tour are requested to communicate with the travel bureau, The Henry Tours, Inc., 565 Fifth Avenue, New York, N. Y., which will make arrangements. The bureau will give information on all matters.

Pacific Coast Convention, Spokane August 28-31

Already plans are well under way for the Pacific Coast Convention, to be held in Spokane, Wash., August 28-31.

A widely varied technical program will be arranged and the following subjects will probably be treated: Transmission-line studies including lightning investigations, corona, and swinging of conductors; interconnection, carrier-current relaying and communication; automatic stations; cables; vacuum tubes; telephony; railway electrification; automatic train control; electrometallurgy of zinc; etc.

Further information will be published in subsequent issues of the JOURNAL.

Regional Meeting in Atlanta October 29-31

The Southern District of the Institute will hold a three-day regional meeting in Atlanta, Ga., October 29-31, with headquarters at the Hotel Biltmore.

A program of special attractiveness to members in the southeastern States is being planned by the regional committee. More details will be announced when the plans are completed further.

Southwestern District Holds Good Meeting in St. Louis

A most successful Regional meeting was held by the Southwestern District of the Institute at the Hotel Coronado in St. Louis, March 7-9. Over five hundred registered at the meeting, and the attendance at the various technical sessions, entertainment features and inspection trips, was exceptionally good.

Four technical sessions were held. A digest of these sessions is given in subsequent paragraphs.

One of the features of the meeting was a conference of Branch Counselors and Students. A report of this is published on another page of this JOURNAL.

On the evening of March 7 a lecture on the subject of "Lightning" was given by F. W. Peek, Jr., in the Engineers Club. Mr. Peek spoke on the artificial production of lightning and announced for the first time the development of a lightning generator for 3,600,000 volts. He described also methods for protection of transmission lines, oil tanks, etc., from damage by lightning. The lecture was followed by entertainment and dancing.

The main social event of the meeting was the Dinner-Dance on the evening of March 8. Following the dinner an address was given by Charles E. Cullen, Professor of Law and Business Administration at Washington University. After this, dancing was enjoyed.

A luncheon was held on March 7 with the St. Louis Electrical Board of Trade, at which about four hundred were present. Bancroft Gherardi, President of the A. I. E. E., made an address on trans-oceanic telephony.

Many of those in attendance took the inspection trips to the Southwestern Bell Telephone Building, Cahokia Power Station and other interesting points.

DIGEST OF TECHNICAL SESSIONS

Electrical Machinery

The first technical session held on the afternoon of March 7, A. E. Bettis presiding, opened with an address of welcome by Mr. Bettis and a few remarks by President Gherardi. The first paper, *Magnetic Leakage and Fringing-Flux Calculations* by W. L. Upson and E. L. Furth, was presented by Professor Upson. In the following discussion by Hans Weichsel he warned that the leakage coefficient and corresponding field ampere-turns vary greatly with the saturation of the poles. B. T. McCormick said that one is justified in using empirical methods because the behaviour of the constructed machines is likely to vary from design predictions. J. L. Hamilton said that there is no occasion for drawing curved lines to represent the fluxes in air gaps and that calculations using straight lines are sufficiently accurate. Professor Upson said that the straightness of the lines was not of great importance, but he wished to point out that magnetic lines do issue from the pole pieces all the way up their sides.

The next paper, *Squirrel-Cage Motors with Split Rings* by Hans Weichsel, was read by B. T. McCormick. In commenting upon this paper, D. D. Clark stated that the power company has an interest in the question of splitting the rings of a motor, as such a motor when connected to a line will tend to cause fluctuations in the voltage of such frequency that they are very noticeable on lights. He was glad to see this proof that such splitting of the rings does not result in any operating advantages and therefore need not be resorted to by consumers. K. L. Hansen disagreed with Mr. Weichsel on one point, showing that in some cases quite an appreciable increase in the intial starting torque may be obtained by splitting the rings. He pointed out also that such a motor would probably have a tendency to hang at half speed. Mr. McCormick pointed out another disadvantage of splitting the rings, namely, that the split rings are likely to be damaged by centrifugal force, as they would not be normally braced to withstand this force.

A. F. Kenyon then read the next paper on the program, entitled *The Drive of Tandem Rolling Mills*. In commenting on this paper, several steel-mill men stated that in practise they would prefer to have a speed regulation on the motors of not over 2 per cent. They stated that 5 per cent or the 8 per cent mentioned by Mr. Kenyon, was too great. One of the advantages of using d-c. equipment, according to Mr. Starbitz, is that regeneration may be employed in stopping the mills. This is quite necessary on some of his mills, where due to roller bearings and fly-wheels, the mills will coast from 12 to 15 minutes. With regenerative breaking they may be stopped in 45 seconds. W. M. Ballinger pointed out that it is advisable to use a-c. motors wherever possible, in order to avoid conversion losses, and with this Mr. Kenyon agreed. Mr. Kenyon also pointed out that difficulties may arise when certain of the driving mills are supplied from one set of busses and others from another set.

Power Systems—A

In the second session, L. F. Woolston presiding, the following four papers were presented: *The Public Utility Laboratory and Its Relation to Service*, by G. E. Meredith and D. D. Clark; *Recent Developments in the Application of Demand-Metering Equipment* by Stanley Stokes and L. V. Nelson; *Excitation Systems—Their Influence on Short Circuit and Maximum Power*

by R. E. Doherty; and *Voltage Regulators* by R. M. Carothers and C. A. Nickle.

R. H. Park pointed out that with the new regulator described in the last paper the gain in the load which a generator can carry before the system becomes unstable, is greatly increased in practise. For instance, for a 250-mile line between a generator and motor, the gain is 55 per cent. For a 500-mile line the gain is 25 per cent. A regulator without the d-c. coil will give only 4 per cent for a 250 mile line and 2 per cent for a 500-mile line. In addition, there will be hunting, which is not found with the new regulator. He pointed out also that with actual large generators used in power plants, the exciter speed need be only half as much as was attained in the tests. C. A. Powell pointed out that stability under transient conditions rather than static stability, is necessary. He said also that an a-c. controlled regulator is suitable for use under transient conditions, and moreover, that operating a system with steady loads in the zone of artificial stability requires that the generating units be worked at very high values of excitation, and it may be more desirable either to increase the static limit by reducing the reactance of the generators or to supply the excitation at more appropriate locations as by using intermediate synchronous condensers. R. D. Evans also pointed out that the transient limit is the more important one. He said that it has been established that a system will reach a critical point in its oscillation in a time of the order of ¾ second from the start of a disturbance, so that any corrective action to be effective, must be made in less than that time. He pointed out, however, that there is an optimum condition beyond which the advantages of further changes are relatively hard to obtain. Up to the point where the magnetizing action of the excitation system is equal to the demagnetizing action produced by the disturbance, the time constant of the main motor field does not enter into the problem. Beyond that point the improvements from the stability standpoint become relatively less in proportion because of saturation in the main machine. He stated that he does not advocate as a normal procedure continuous operation in the zone of artificial stability. H. W. Smith stated that the regulator in which the vibrating system is actuated only by the terminal voltage of the main machine, has shown quite satisfactory results and allowed large increases in power limits on artificial lines. With the 3-coil regulator he said there is a possibility that in the event of a drop in terminal voltage, its contacts may open before normal terminal voltage is regained. The regulator with the a-c. vibrating coil does not have this disadvantage. With a corresponding change of 10 per cent in terminal voltage, the contacts close and remain closed until normal terminal voltage is restored. J. H. Ashbaugh advocated the use of the rheostatic regulator because it is as sensitive as the vibrating regulator and does not possess its imperfections. He stated that it appeared to him that the 3-coil regulator approaches the performance of the regulator with two a-c. coils more closely than the regulator with a-c. and d-c. coils. He said that the function of the d-c. coil is merely to prevent hunting, but upon a reduction in a-c. voltage the regulator would start vibrating before the exciter reaches its maximum voltage, which is undesirable. C. A. Adams said that he believed that any improvement in regulators is desirable, and that a regulator which makes it possible to operate closer to the maximum limit, is a considerable gain, even though operation is not normally carried on near this limit.

Power Systems—B

The first session on the morning of March 9, S. M. DeCamp in the chair, opened with the presentation of *Development of Impedance Relays*, by H. A. McLaughlin and E. O. Erickson. In discussing this paper, H. P. Sleeper stated that in his opinion impedance relay has for its principal application its use on complicated systems. It may be used in a network to take care of a certain line by reason of faults on that line, independently of the time elements in other sections of the system. He mentioned that there are definite limitations to the application of this relay. It should not be used for balanced protection of parallel lines, but it can be used to back-up the balanced relays, that is, after one line has been disconnected, the impedance relay can be used to protect the single line that remains. He said that his company has had very satisfactory results with this relay and that the danger of incorrect setting is very small. He asked if it is possible to speed up the zero voltage operation of the relay; also, if trouble is to be anticipated by the additional time introduced by the interlocking of the directional element with the operating element. W. H. Millan also advocated the use of the impedance relay as a back-up relay and said that on his system it could, with good advantage, be used to replace some of his present overload back-up relays. O. C. Traver said that he had a feeling against putting this type of relay at the generating end of a system and that he preferred a straight over-current relay in this position. He mentioned that his company has employed for ten years the 90-degree method of connecting the relay to the line, and that he thought this method could be profitably applied to the impedance relay. In answering Mr. Sleeper's questions, Mr. McLaughlin said that the zero-voltage time is now as low as it has been possible to make it. In regard to the time delay introduced by the directional element, he explained that the voltage used on the directional element differs from the voltage used on the impedance element, so that for a line-to-line fault the voltage on the impedance element will never be reduced to less than line-to-ground voltage; likewise, for a ground fault the voltage on the directional element differs from that on the restraining element, and will never be reduced to less than line-to-ground voltage. The resultant additional time will be only about 2 or 3 cycles. When using the impedance relays on a system with other relays, they will give a definite gain in results when located at the generating station.

Automatic Switching of Incoming Lines and Transformers Supplying Power to A-C. Sub-Stations by A. E. Anderson, was the next paper presented. R. J. Houk, commenting on this paper, called attention to the fact that protective relaying should be given special study where automatic switching is used. Chester Lichtenberg emphasized the same thought and added further that maintenance and inspection are really the basis of successful automatic operation. He advocated the use of one set of instruments such as synchronizing relay, reclosing relay, etc., for each circuit breaker rather than one over-all set of relays controlling a number of breakers.

J. B. MacNeill presented the next paper entitled *Moderate-Voltage, Moderate-Capacity, Round-Tank Circuit Breakers*. R. R. McGee pointed out the striking similarity in fundamentals of design between the new moderate-duty breaker and the new large breakers made by the principal manufacturing companies. He described a number of the breakers made by his company.

The last paper in the session, *Vibration of Transmission-Line Conductors* was presented by the author, Theodore Varney. D. D. Clark mentioned that his company had experienced breakage of supports, which was apparently due to this vibration of conductors. Eli Etlinger said that his company has suffered from breakage of conductors caused evidently by vibration, and that the breaks appeared to have been caused by a shearing force and not by tension. He advocated that ground wires be supported as flexibly as possible, to avoid such breakage. In closing the discussion, Mr. Varney said that his experiments indicated that the breaking of wires was practically due to beinding. He said that a theory had been advanced that there must be a longitudinal wave in addition to the transverse vibration. He contended, however, that the velocity of the longitudinal wave would be 10 or 12 times the velocity of the transverse wave, and that it would not have any great damaging effect. He said that if tension is reduced, the bending effect would be reduced, but of course other difficulties will result due to having a loose line which might swing considerably.

COMMUNICATION

The last session, on the subject of communication, was held on the afternoon of March 9, with B. D. Hull presiding. The first paper *Vector Calculating Devices*, was presented by the author, M. P. Weinbach. Some of the discussors mentioned that somewhat similar schemes to those proposed by Professor Weinbach had been advocated by others. J. W. Arnold deprecated the fact that a slide rule for complex numbers is not on the market. The reason he thought is not so much that the demand does not exist, but that engineering opinion has not settled upon a particular design as most desirable.

W. B. Stephenson then presented his paper, *Planning Telephone Exchange Plants*. E. N. Widen, commenting on this paper, drew attention to the importance of population forecasting in planning telephone systems. He said that the principal population-supporting activities of a community must be considered from a national and even international viewpoint, and that such procedure ordinarily leads to less optimistic conclusions than those reached by local judgment, but they are more likely to be realized. H. R. Fritz elaborated on another point of the paper, namely, the zoning of instruments and other equipment. Placing the more efficient instruments at the greatest distance from the central offices, permits the maximum and most economical use of the several sizes of exchange cable without having to abandon the use of the less efficient subscriber's sets.

Professor R. S. Glasgow then presented his paper, *Tuned Radio-Frequency Amplifiers*. In commenting on the paper, Stanley Stokes mentioned that the cutting of side bands might not have such a serious effect on broadcast reception because probably only a small portion of the waves broadcast have a frequency over about 3500 cycles.

The last feature on the entire program was the lecture on Television, by H. E. Ives. Dr. Ives presented an interesting account of the development of television apparatus and systems, and gave a number of demonstrations with television equipment.

New York Section Student Convention and Annual Meeting

On Thursday, April 19th, the New York Section will hold its regular monthly meeting and third Annual Student Convention.

The Student Convention, the program for which has been arranged entirely by a committee of students, will occupy the morning and afternoon of the 19th. Inspection trips for students only will take up the morning. During the afternoon representatives of the eight colleges in the Section will present papers in competition for the prize of $25 in gold offered by the N. Y. Section Executive Committee. Following the afternoon session a Student Dinner will be given at the Fraternity Club, 38th St. and Madison Ave., New York. An engineer of prominence will give a short talk at the dinner.

The evening session, the regular N. Y. Section meeting, will be devoted to a paper on "Some Recent Developments i Dial Systems" by Messrs. H. M. Bascom and W. E. Farnham of the American Telephone and Telegraph Company. At this meeting announcement of the election of N. Y. Section officers for 1928-1929 also will be made.

International Congress on Illumination

An International Congress on Illumination, to bring together the world leaders in the field of lighting from all parts of the world, is to be held in the United States in September, 1928. The International Congress, which will open on September 7th with a tour by the foreign delegates to various American cities, will include the Twenty-second Annual Convention of the Illuminating Engineering Society at Toronto September 17-20, and close with the Eighth Session of the International Commission on Illumination, to be held at Saranac Inn., N. Y. from September 22nd to 28th inclusive.

Announcements are now being prepared to be sent to lighting experts, university professors and to other prominent engineers in the principal countries of the world.

Arrangements are under the auspices of the Illuminating Engineering Society and the U. S. National Committee of the International Commission on Illumination. John W. Lieb, vice-president and general manager of the New York Edison Company and past president is serving as chairman of the Reception Committee. Julius Daniels, The Edison Electric Illuminating Company of Boston, is chairman of the Executive Committee in charge of arrangements.

World Engineering Congress, Tokio

At a dinner given in honor of the American Committee at the Carlton Hotel, Washington, by the Japanese Ambassador, Tsuneo Matsudaria, on the evening of March 22, the Committee on American Participation in the Engineering Congress which will be held in Tokio in October 1928, was formerly organized.

The Japanese Ambassador said that both Japan and the Engineering Society of Japan, under whose auspices the Congress in Tokio will be held, were gratified at the interest being shown in the coming Congress by engineers in the United States.

Dr. Elmer A. Sperry, of Brooklyn, who was elected Chairman of the American Committee, pointed out that human welfare is largely dependent upon the activity of engineers and scientists. The coming together of engineers and scientists with the consequent comparing of data and experiences, Mr. Sperry said, will not only advance the world's engineering status and contribute to world prosperity, but will simplify production and minimize variations particularly if international engineering standards are established.

The following officers of the American Committee, which will arrange for the attendance of a large delegation of American engineers at the Congress in Japan, were elected: Honorary Chairman, Herbert Hoover; Chairman, Elmer A. Sperry, New York; Vice-Chairman and Chairman of the Executive Committee, John W. Lieb, New York; Vice-Chairman: C. E. Grunsky (Pacific Coast) San Francisco; C. E. Kettering (Middle West) Detroit; Executive Secretary, Maurice Holland.

Chairmen of committees were appointed as follows: Finance, John W. Lieb; Technical Program, D. C. Jackson; Transportation, F. B. Jewett; Entertainment, O. C. Merrill; Publicity, J. H. McGraw; Promotion and Attendance, George W. Fuller; Nominations, Gano Dunn.

The following members of the Institute, all of whom are included in the membership of the American Committee as appointed some months ago by Honorary Chairman Hoover, were in attendance: Edward Dean Adams, A. W. Berresford, C. C. Chesney, Gano Dunn, Bancroft Gherardi, F. L. Hutchinson, D. C. Jackson, A. E. Kennelly, O. C. Merrill, C. W. Rice, Charles F. Scott, Elmer A. Sperry, Lewis B. Stillwell, Calvert Townley, William E. Wickenden.

Digest of Discussion at Winter Convention

ELECTROPHYSICS AND DIELECTRICS

Surge Impulse Breakdown of Air, J. J. Torok

Influence of Internal Vacuua and Ionization on the Life Duration of Paper-Insulated, High-Tension Cables, A. Smouroff and L. Mashkeileison

Approximate Solution for Electrical Networks, E. A. Guillemin

The Boltzmann-Hopkinson Principle of Superposition, F. D. Murnaghan

In discussion the first paper, C. L. Fortescue brought out some practical deductions from the results obtained with the suppressed flashover of spheres. He explained that breakdown is not an instantaneous process and how flashover with the steeper wave fronts requires more time. He explained how Mr. Torok's data showed that even the sphere-gap has an appreciable time

lag, though it is very small. He explained how the voltages in surges caused by lightning strokes are not as high as might be expected because such a surge is dynamic and divides itself into waves. J. A. Duncan suggested that possibly the generation of ultra-violet light may assist in breakdown and that this might be an explanation of the short time lag. Joseph Slepian said that Mr. Torok's pictures and data prove that the Townsend theory of breakdown of spark-gaps apparently fails at atmospheric pressures when the speed of breakdown is considered. According to the Townsend theory, he said, the whole path would first be slightly broken down and then more and more intensely, while the pictures actually show the path completely broken down in part and not at all broken down for the remainder. He stated that these pictures suggest that the trail left behind by the initiating electron is highly conducting and that possibly at atmospheric pressures the multiplication by collision of the initiating electron is so rapid and the path is of such small section that the passage of this electron with its accompanying new electrons is enough to raise the temperature of the path to such a high degree that it is thermally ionized and highly conducting. He was not sure, he said, that the streamers propogate from both electrodes. F. W. Peek, Jr., said that Mr. Torok's results checked very closely with the tests and calculations which he has made on breakdown. He stated that he has employed considerably over 2,000,000 volts and the results at this voltage checked very well. He has also checked his former work and calculations by means of the DeFour oscillograph and the check was very good. In his closing discussion, Mr. Torok pointed out that his photographs were made with one single shot of voltage. He said that he had considered the suggestion of the effect of ultra-violet light but could not find that it could be applied in this case from the energy standpoint.

In discussing the second paper, W. A. Del Mar said that he had made experiments that confirm the reports in the paper that there is a very definite connection between the pressure and the cable life. A number of the discussors pointed out that the tests described in the paper had evidently been made on cable which was quite inferior to modern American cable. C. L. Dawes and W. F. Davidson both pointed out the necessity for thorough shielding and stated that there was apparently no shielding of that part of the cable sheath used for the test electrodes, which might possibly cause an error in the results. Mr. Dawes said that the power-factor computations made in the paper appeared to be in error and that investigations which he was making showed that after the ionization voltage is reached the power loss becomes lower on further increase of voltage and thus is not constant. E. H. Salter said that some of the pressure measurements might contain errors and suggested the use of a solidly connected manometer with the lead tube filled with oil and that readings be taken by bringing the mercury column always back to the same zero point. L. H. Connell questioned the pressure measurements, pointing out that pressure transfer through or along cable insulation is very slow and is a function of temperature. He said that measurements of power factor might be too high because as the voltage is raised so that it gives greatest power factor, pockets of gas which were too small to ionize at the lower voltages ionize and thus make an increased loss. His experiments, he said, indicate that there is no reaction in cable compounds which operates to reduce their volume materially. He disagreed with the suggestion that chemically stable compounds are a cure for vacuum troubles. He disagreed with the supplying of air to prevent vacuum formation and claimed that air must be kept out of cables because the most chemically stable oils will oxidize in the presence of oxygen, and oxidized oil under such conditions is highly acidulous. He stated that oil on the joints of cables of the ordinary type will not prevent vacuum formation 20 ft. away under normal load changes. E. S. Lee gave the results of some tests which corroborated the general conclusion that low internal pressures give shorter life while high pressures give longer life.

In discussing the fourth paper, J. B. Whitehead explained that it was a mathematical analysis of the relation between superposition and Maxwell's theory of dielectric absorption, and stated that the conclusions showed that the principle of superposition is valid for the displacement in a layer dielectric but for not for the total current. Practically all of the discussors agreed that the principle of superposition is valid for elementary dielectrics but that it fails for composite dielectrics and for any reasonable range of voltage gradient. Dr. Murnaghan stated that his paper was not a plea for a favorable view of Maxwell's theory of dielectric absorption but was merely a completion of the mathematical argument and was, he believed, the first solution of the superposition principle for the current as distinguished from the displacements in the various layers of the dielectric.

Communication

Transatlantic Telephony—The Technical Problem, by O. B. Blackwell.

Transatlantic Telephony—The Operating Problem, by K. W. Waterson.

Loudspeakers of High-Efficiency and Load Capacity, by C. R. Hanna.

Certain Topics in Telegraph Transmission Theory, by H. Nyquist.

In commenting on Mr. Hanna's paper, Harvey Fletcher spoke of another type of loud speaker which has been developed, in which the driving coil is connected directly to the diaphragm. In this speaker, with the form of air chamber employed, it is possible to use a larger diaphragm without sacrificing efficiency at the high frequencies, thus making it possible to radiate more energy at the low frequencies. As commercially produced, this speaker has an average efficiency of about 30 per cent. The diaphragm, he said, has about one-half the thickness of Mr. Hanna's diaphragm and has been found to be free from resonance. He also mentioned certain methods of measuring the absolute efficiency of the receiver, which have been employed. A. E. Kennelly drew attention to the similarity between the "acoustic circuit" mentioned in this paper and the common electric circuit. He urged the adoption of a more convenient nomenclature for mechanical and acoustical impedances. W. C. Jones said that experience in producing talking motion pictures has shown that a single large speaker of the lumped-constant electrodynamic type can be operated without serious distortion at outputs three to four times higher than the limiting level of 0.6 watt set by the paper. The limiting factors appear to be heating and mechanical strength rather than distortion due to air-space phenomena. He also stated that with certain cobalt alloys, air-gap densities of 20,000 gausses are practicable. In closing the discussion, Mr. Hanna said that the diaphram dimensions had been selected by experience as the most satisfactory. He stated that he believed that some resonance does occur in the diaphragm mentioned by Mr. Fletcher at frequencies from 3000 to 5000. He stated that the spring mounting of the driving coil gives greater load capacity than the solid structure on account of the greater air cavity possible. Another advantage of the compliance method he claimed is that for a given field density the efficiency will be higher. He pointed out that the field density required to obtain equal efficiency in the lower frequency elements is less than 12,000 gausses, becauses a greater mass of conductor may be used in the moving coil; in the bass unit for example, the field strength is about 5000 gausses and the coil which drives the diaphragm weighs nearly half a pound.

Control and Protective Equipment and Substations

Automatic Control of Edison Systems, by O. J. Rotty and E. L. Hough.

Protection of Supervisory Control Lines Against Overvoltage, by Edward Beck.

1926 Lightning Experience on 132-Kv. Transmission Lines, by Philip Sporn.

Vacuum-Tube Synchronizing Equipment, by T. A. E. Belt and N. Hoard.

Use of Condenser-Type Bushing in Synchronizing, by E. E. Spracklen, D. E. Marshall and P. O. Langguth.

In discussing the first paper, Caesar Antoniono said he was very enthusiastic about automatic operation, as it has reduced his company's operating costs and made it possible to give better service without a prohibitive capital investment. Herman Bany called attention to the completeness of the St. Charles Street equipment, but pointed out that if the requirements are such that simpler equipment will meet them, the simpler method should be used. He added also that evidently great confidence had been placed in the automatic stations in St. Louis, as it had not been considered necessary to employ a standby battery on the system. In answering a question, E. L. Hough said that no difficulties had been experienced in tying together the 25-cycle and 60-cycle systems through the d-c. network, because the two a-c. systems are tied together only through the feeders and at their nearest points are separated by approximately three blocks. H. L. Wallau commented on the excellent service which had been obtained in Cleveland from extensive use of automatic stations.

Following the second paper, G. D. Floyd read a discussion by C. F. Publow, in which was mentioned a case of trouble on a supervisory circuit resulting in damage to the control wires and cable sheath at times of disturbance on the main lines. The discussion stated that since the installation of protective transformer equipment on the supervisory lines in over 1½ years of service, these lines had been very satisfactorily protected though lightning storms had been frequent and there had been a number of insulator spill-overs. Chester Lichtenberg pointed out that the standards of maintenance on supervisory lines should be higher than those ordinarily employed on communication circuits. Lightning arresters, he asserted, must be self-restoring; that is, they must be capable of discharging without fusing or making a permanent connection, as is the case with carbon-block arresters used on telephone lines. He claimed that the use of pellet-type arresters with high-voltage fuses, at the stations, had satisfactorily taken care of lightning, electromagnetic induction, and in one instance direct contact with high-voltage lines on an extensive carrier-current supervisory system 60 mi. long and partly carried on the same poles with 33,000-volt power circuits. Caesar Antoniono also warned that supervisory control lines should ordinarily be in better condition than telephone lines. He said that he believed there is still room for improvement in making the supervisory control systems trouble-proof. In closing, Mr. Beck stated that it is most desirable to have the ground resistance not over a few ohms or a fraction of an ohm.

In a discussion on Mr. Sporn's paper, A. O. Austin claimed that one of the most serious problems for the designer of an insulator or transmission line is to prevent the flashover of an insulator under oscillating conditions or after the crest of the voltage wave has materially decreased. He suggested the use of high-resistance ground wires as a possible preventive of insulator flashover or damage to station equipment from this "tail" of the voltage wave. The high-resistance ground wire or preferably several of them, will tend to absorb more of the energy of the wave than would be absorbed by a low-resistance wire, and thus reduce the transient voltage at a fast rate. He suggested skipping the grounding on some of the poles as one method of obtaining this higher resistance. In his closing discussion, Mr. Sporn pointed out that storm data obtained from the records of one locality cannot be applied to another locality where weather conditions may be different. In answer to a statement by Mr. Austin, he declared that he had obtained a very large number of klydonograph records on a 132-kv. system and had never obtained a record of a flashover at 400,000 volts of an insulator string whose crest flashover voltage was 1100 kv. In answering one of the discussors, he said that he did not believe that at 132,000 volts there is enough effect on the present protective devices to allow them to act very greatly in holding back flashovers; that is, there is not sufficient grading at 132,000 volts to increase the lightning flashover of the insulator string at high voltage, though at 220,000 volts this undoubtedly does come into play.

H. L. Crumley said that his company has had entire satisfactory experience with the vacuum-tube synchroscope. He stated that his experience showed that impulse voltages had caused no damage and that in one case the upper portion of the bushing had been split and that synchronizing had been carried on satisfactorily after this occurred.

E. D. Eby showed that the accuracy of the synchroscope is only very slightly affected by variation of the shunt resistance, the condenser resistance, the presence of external metal structures, changes in the external leakage resistance of the bushing or varying temperature. He also remarked on the high safety factor of the device. Philip Sporn pointed out the relative economy of using the synchronizing equipment discussed in the last two papers, and said that in his opinion the straight condenser method is apparently simpler but it appears that the vacuum-tube method has more than enough other advantage to compensate. He stated that in a certain 132,000-volt switching station, he had occasion to synchronize six circuits against either one of two busses. The cost of doing this by the vacuum-tube arrangement was approximately $8400, while the estimated cost for accomplishing the same thing by standard 132,000-volt potential transformers was $34,000. Mr. Langguth enumerated four general uses of the condenser-type bushing, which were as follows: (1) with a synchroscope for synchronizing high-tension lines, even of different voltages; (2) operation of frequency meters; (3) use with voltmeters for indicating the presence and approximate value of voltage on a line; (4) application for protection of systems against faults between phases and from phase to ground, the last use, however, being still in somewhat of a development stage.

Arc Welding

Effects of Surface Materials on Metallic Arc Welding Electrodes, by J. B. Green.

Arc-Welding-Influence of Surrounding Atmosphere on the Arc, by P. Alexander.

Arc-Welded Structures and Bridges, by A. M. Candy.

Welding and Manufacturing of Large Electrical Apparatus, by A. P. Wood.

In answering several questions on his paper, Mr. Green stated that the electrodes shown in his illustrations were 3/16 in. in diameter and that the currents were about 150 amperes. Low currents were used in order that the melting rate of the electrode might be slow, which would allow more satisfactory taking of the pictures. He said that the flux materials employed were used only for demonstrating certain phenomena and that they were too expensive and otherwise unsuitable for practical use. He explained that the eratic behavior of some of the arcs was due to the relative resistances of the possible paths between the electrodes and the deposited metal. A constant potential with a large ballast resistance was employed in the demonstrations. He stated that in his opinion fluxes are used in gas welding largely to dissolve the oxide, while in electric welding the function of the fluxes is one of arc-heat distribution.

Dr. Elihu Thomson gave a brief summary of the points in Mr. Alexander's paper, explaining that the phenomena of welding must be studied from both the chemical standpoint and the thermodynamic standpoint. Eugene Herzog disagreed with the author on one point, namely, the application of Langmuir's dissociation theory to carbon monoxide. He said that it did not seem logical to assume that the fact of no energy absorption would explain the stabilizing influence of carbon monoxide on the arc. Mr. Alexander said that the absence of absorption of energy does not explain the stabilizing properties of carbon monoxide; it explains only why, in spite of the observed disso-

ciation of a certain amount of carbon monoxide, the arc core is not cooled by this reaction. He stated that the development of the shielded arc process is still going on though this process has not been commercialized. In experimental work, he said, atomic hydrogen had been used for welding plates 2 in. thick, but in practical work thicknesses of over ¼ in. are not usually recommended. He said he believed that welds made with this process should resist corrosion better than the ordinary type of weld.

J. W. Owens, commenting on Mr. Candy's paper, denied that there is any advantage in possible slippage of riveted joints, as is claimed by some advocates of riveting. Once a riveted joint starts to slip, unbalanced stresses may be set up in other parts of a structure, which stresses have not been provided for in the design. He predicted that in the near future, perhaps the next ten or fifteen years, ships will be completely welded. He stated that the largest ship built in America, the *California*, has all her pillars welded at top and bottom, and that practically all parts of the inside of ships are now being successfully welded. A. P. Wood advocated the use of automatic welding wherever possible. He pointed out that his company had found that a very large saving had been affected in welding wire by employing the automatic process, because in hand-welding the operators usually throw away a considerable length of the electrode

In discussing Mr. Wood's paper, F. D. Newbury emphasized the fundamental importance of the change in machinery construction brought about by the use of welding. To take advantage of the new construction, he said, the structure must be designed for welding rather than for casting. The new method, he stated, is particularly applicable to special designs of larger machines that are seldom duplicated. For some large machines, he said, the base plate can be made in less time and for less money than the pattern for a cast base plate would cost. B. L. Barns pointed out that a very important advantage of welded construction is the greater freedom of the design in using dimensions and proportions best suited for the electrical characteristics that are desired. Another advantage, he mentioned, is that there is little reduction in delays in manufacture due to defective castings.

Engineers' Memorial at Louvain

The 48-bell carillon and the clock with the 48 "gold" stars are being produced rapidly. The tower of the new Louvain Library is ready to receive them for the engineers of the United States as their reminder of their fellows who died in the Great War. The carillon will have several novel features, including electropneumatic devices to assist the player. The clock dials were modelled by Rene Chambellan of New York, a former member of the 11th Engineers, as a tribute to his comrades. The King and the Queen of the Belgians will preside at the dedication next Fourth of July. Mr. Josef Denyn, most noted of the carillonneurs of Belgium, has composed the quarter-chime tunes for the clock and bells, in response to a special request from the Committee on War Memorial to American Engineers. He will give a recital on the new carillon in connection with the dedication. Throughout the centuries to come these memorials will proclaim American goodwill to Europe through the sweet tones of the skillfully tuned bells.

The Institute has appointed as its official representatives to attend the dedication of the Louvain Memorial on July 4, 1928, and Edward Dean Adams, Dr. M. I. Pupin, Dr. John W. Lieb, Dr. Dr. William H. Onken, Jr.

Research Fellow Appointments at Wisconsin

Two research fellowships in engineering are to be appointed on April 30 by the University of Wisconsin. Candidates must be graduates of engineering colleges of recognized standing, and, preferably, should have had one or two years of graduate study, of teaching, or of engineering experience. Applications will be received up to April 15. Information and application blanks can be obtained from Dean F. E. Turneaure, College of Engineering, Madison, Wisconsin.

The appointments will be for a period of two years, subject to satisfactory service, and the salary will be $900 for the first year and $1100 for the second year. A Fellow will be expected to devote not less than half time to assigned research in the College of Engineering, but will be given an opportunity to complete the requirements for a master's degree within the two-year period. The period of service will be the usual academic year, including the short vacations.

Cooper Union Offers Honor Courses for Engineers

Dean F. M. Hartmann, announces that honor courses for students of unusual ability will be given in the Institute of Technology at Cooper Union, beginning with the school term of 1928-29. Four-year courses in civil engineering, electrical engineering, mechanical engineering, and chemical engineering are offered free.

"This inauguration," Dean Hartmann explains, "will permit the student who has proved himself capable especially in his junior year, to select at the beginning of his senior year, in addition to his regular schedule, some special topic for survey and study.

"To be permitted to take an honors course, the student must have made an average grade in the sophomore year of not less than eighty per cent, and in the junior year grades of 'A' in the subjects directly related to the topic he has chosen. There must be an average of not less than eighty-five per cent in the remainder of his subjects."

Teaching Fellowships in Electrical Engineering University of Minnesota

Three teaching fellowships, paying $750 per college year, are offered by the University of Minnesota for the year 1928-29 to graduate electrical engineers. These positions require half-time in instruction and assistant work, thus permitting a Master's degree to be obtained in two years. The appointments are made for one year with the expectation of continuing the second year if satisfactory.

Research problems in power, communications, illumination, measurements, etc., are available.

Those interested should send complete information, including references, photograph, personal data, and desired research subject to the Electrical Engineering Department, University of Minnesota, Minneapolis, Minnesota.

Members Going Abroad

Members of the Institute who contemplate visiting foreign countries are reminded that since 1912 the Institute has had reciprocal arrangements with a number of foreign engineering societies for the exchange of visiting member privileges, which entitle members of the Institute while abroad to membership privileges in these societies for a period of three months and members of foreign societies visiting the United States to the privileges of Institute membership for a like period of time, upon presentation of proper credentials. A form of certificate which serves as credentials from the Institute to the foreign societies for the use of Institute members desiring to avail themselves of these exchange privileges may be obtained upon application to Institute headquarters, New York.

The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Societe Francaise des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V.

(Germany), Denki Gakkwai (Japan), Norsk Elektroteknisk Forening (Norway), Elektrotechnicky Svaz Ceskoslovensky (Czechoslovakia), and The Institution of Engineers, Australia (Australia).

Appointment for Engineering Foundation

Engineering Foundation announces that at the meeting of the Board of Trustees of United Engineering Society on 22nd March, Mr. Herbert Hoover was appointed a member of the Endowment Committee for Engineering Foundation and Engineering Societies Library, and its Executive Sub-Committee.

Mr. Hoover who is a Past-President of American Institute of Mining and Metallurgical Engineers, Honorary member of American Society of Civil Engineers, and a member of the American Society of Mechanical Engineers, will assist in investigating the many problems in applied science outside the fields of activities of industrial and governmental research laboratories which are brought to the engineering societies and their Foundation.

Ohio State Fellowship

The Ohio State University announces the Stillman W. Robinson fellowship having an annual value of $750, for graduate study and research in electrical, mechanical, or civil engineering. Further information may be obtained from the Dean of the Graduate School, Ohio State University, Columbus, Ohio.

United Engineering Society

SOCIETY TRUST FUNDS

Members of the Founder Societies will be interested to know how well the joint trust funds of the Societies are administered by United Engineering Society. A report of a review and analysis of securities made 9th February by The Farmers' Loan and Trust Company, gives this information. This trust company is one of the oldest and most conservative in New York. The report covers the endowment funds for Engineering Societies Library, Engineering Foundation and John Fritz Medal, and the Depreciation and Renewal fund for Engineering Societies Building. In round figures, these funds severally total

Engineering Societies Library	$160,000
Engineering Foundation	610,000
John Fritz Medal	3,500
Depreciation and Renewal Fund for building	210,000
General Reserve	10,000

The present total market value nearly equals the par value and is substantially in excess of the book value, or cost.

The report states: "The indicated direct return is 4.92 per cent which seems quite satisfactory considering the high character of the securities held. In this connection, it is interesting to note that among all the bonds represented, there are only two to which Moody assigns a rating lower than "A" and only three which are rated "A", the remainder being all "AA" or better. The diversification appears to be good, as the largest single item which consists of $90,000 par Interboro Rapid Transit 1st and refunding 5's of 1966, is less than 1/10 of the total par value of the account and their market value is only about 1/15 of the total market value.

In general, it is our feeling that the Society is to be congratulated upon the fine character of its investments."

This evidence of competency to manage funds should be reassuring to persons in position to make additions to the endowments of the Library and Engineering Foundation.

ANOTHER BEQUEST

The United Engineering Society has just received a bequest of $1000 through the will of the late Oberlin Smith, president of the American Society of Mechanical Engineers in 1890. Mr. Smith founded the Ferracute Machine Company, Engineers, Bridgeton, N. J. and was its head. He invented and designed most of its products, consisting of some automatic machinery, but chiefly presses and dies for stamping and otherwise treating metals of all sorts. He invented and patented more than 50 devices in a variety of engineering work. He wrote and published "Press Working of Metals," also numerous lectures, scientific articles, and a semi-scientific and semi-theological essay entitled "The Material, Why Not Immortal?" He was at various times a member of the American Societies of Civil, Mining, Mechanical, and Electrical Engineers.

Italian National Research Council

On account of the necessity of coordinating and regulating scientific research in Italy, Premier Mussolini directed a message to Senatore Guglielmo Marconi, on January 1, 1928, inviting him to assume the Presidency of a Committee for the reorganization of the Italian National Research Council, and outlining some of the principal objectives by which the activities of the Council should be guided.

A National Research Council has been in existence since 1921, but it is being reorganized in order to provide for more effective technical progress in Italy and closer contact with such progress in other countries.

A. I. E. E. Year Book

The 1928 issue of the Institute's Year Book is ready for distribution and may be obtained upon application at headquarters. The book contains both alphabetical and geographical cataloging of Institute members, revised to January 1, 1928, together with copy of By-Laws, Constitution, list of offices, list of committees, and other information pertinent to Institute activities.

PERSONAL MENTION

James R. Werth has been appointed head of the New Business Division of the Florida Power & Light Company, Miami, Fla.

Mr. Leo Castellino, who came to America to study American methods of manufacture and production, is going to England where he will be for some time before returning to Bombay, India. Mr. Castellino is identified with the Stone & Webster Company of Boston and has been an Associate of the Institute since 1925.

R. W. Adams, local manager of the General Electric Co. for Rhode Island and Eastern Connecticut, has been given new responsibilities in his appointment as head of the Central Station Department for the New England district of the company. Mr. Adams has been engaged in engineering all his life. He joined the Institute in 1906.

Douglas F. Miner has recently been appointed manager of Material and Process Engineering Department of the Westinghouse Electric and Manufacturing Company. Mr. Miner was first employed by the company in 1919 as an assistant to section engineer of the Electrical Section. Since 1920 he has served in the capacity of section engineer of the Experimental Section of Material and Process Engineering Department.

Mr. Miner has been a member of the Institute since 1921 and has spoken before this body and other engineering groups on the subject high-voltage tests; also he has prepared several articles concerning high-voltage tests and high-voltage laboratory equipment, which were published in A. I. E. E. Journal, *Electric Journal*, and *Electrical World.*

Obituary

Robert Miller, District manager of the General Electric Company, Denver, Colorado, a member of the A. I. E. E. Denver Section and an Associate of the Institute since 1921, died January 5 on the eve of his 48th birthday.

Mr. Miller was born at Baldwinsville, N. Y., was graduated from the Amsterdam High School and was about to enter Cornell University when his father's death occurred, compelling him to change his plans. He became inventory clerk at Schenectady but with rapid progressional transfer from drafting department to division leader of induction motor design and then to the Standardizing Laboratory, in 1911 he was advanced to the position of manager of the Salt Lake City Office of the General Electric Company. He was a public spirited man, a member of many of the local clubs and of the Denver Chamber of Commerce. He had a faculty for clear thinking, and an analytical mind with strong determination for fair dealing. His record is one of valuable contribution to the engineering world.

Engineering Index Service

Of great interest to engineers is the announcement of the Weekly Engineering Index Service supplied by the American Society of Mechanical Engineers. This is an extension of the old Engineering Index which has been of such immense value to members of the profession for the past 44 years.

By this service, material received by the United Engineering Societies is reviewed by a staff of editors qualified by practical field experience, classified under one of the thirteen subject headings in which the different phases of engineering interest are listed, printed on index cards convenient for filing, and sent each week to subscribers.

The classification "Electrical," is sub-divided as follows:

5. *Electrical*: A. Communication,—Telephone, telegraph, radio, television, burglar and fire alarm, etc. B. Industrial Applications—Furnaces, heating, welding, etc. (exclusive of 3F) C. Instruments and Meters. D. Power Plants and Distribution—Equipment, hydro-electric, transformers, transmission lines, etc. E. Theory and Design. F. Electrical Machinery, Apparatus and Supplies—Generators, motors, wiring, switches, etc. G. Illumination—Street, buildings, mines, ships, trains, etc. (electric only). M. Miscellaneous—Other electrical engineering subjects not otherwise classified.

Full information concerning this service, which is supplied practically at cost together with sample index cards may be obtained by addressing Major Carlos de Zafra, director, the Engineering Index Service, 29 West 39th Street, New York, N. Y.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Anyone knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify the Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and also assuring the prompt delivery of Institute mail, the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work.

A. E. Baraker, 916 Southern Blvd., New York, N. Y.
Charles B. Bennett, 917 S. Sarah St., St. Louis, Mo.
Vincent P. Cronin, 141 E. 32nd St., New York, N. Y.
Charles Ewing, 1411 S. 4th St., Louisville, Ky.
Albert S. Walton, 113 Gainsboro St., Boston, Mass.
H. W. Forman, Jr., The Western Colo. Pr. Co., Silverton, Colo.

A. I. E. E. Section Activities

Future Section Meetings

Cleveland

Interconnection of Power Systems, by Philip Sporn, Elec. Engr., American Gas and Electric Co. April 19.

Annual Meeting. Speaker: Pres. Bancroft Gherardi, Vice-President and Chief Engr., American Tel. & Tel. Co. (National President, A. I. E. E.) May 24.

Columbus

Joint meeting and smoker with O. S. U. Branch. April 27.

Household Electrical Engineering, by G. W. Alder, Consulting Engineer, Good Housekeeping Institute. Annual Meeting. Election of officers. Ladies are invited to this meeting, which will be preceded by a dinner. May 25.

Erie

Use of Mechanical Ideas in Electricity, by W. S. Franklin, Massachesetts Institute of Technology. April 17.

Modern Reproduction of Sound, by L. T. Robinson, General Engineering Laboratory, General Electric Co. May 15.

New York

Dramatization of Machine Switching, by W. E. Farnham and H. M. Bascom, American Tel. & Tel. Co. Announcement of election of New York Section officers for 1928-1929. In the afternoon the New York Section Student Convention will be held. Competition for prizes. April 19.

Niagara Frontier

System Insulation and Protection, by C. L. Fortescue, Westinghouse Electric & Mfg. Co. April 20.

Electrification of the Cement Industry, by J. A. Zook, Chief Engr., Great Lakes Portland Cement Co. of Buffalo. May 18.

Pittsburgh

Arc Phenomena, by Dr. Joseph Slepian, Westinghouse Electric & Mfg. Co. April 10.

Household Electrical Engineering, by G. W. Alder, Consulting Engr., Good Housekeeping Institute. Dinner Meeting, to which the ladies are invited. May 8.

St. Louis

Arc Welding, by K. L. Hansen, Consulting Engr., April 18.

Influence of Iron Saturation on the Operation Characteristics of Transformers, by H. Weischel, Wagner Electric Corp. May 16.

Sharon

Lecture on Television. May 1.

PAST SECTION MEETINGS

Boston

Up-To-Date Protection of Lines and Power-Station Apparatus, by K. B. McEachron, General Electric Co. February 9. Attendance 175.

The Budget System of the Commonwealth of Massachusetts and Some of Its Results, by Hon. Wellington Wells, President, Senate of the General Court of the Commonwealth. Luncheon meeting. March 12. Attendance 321.

Columbus

Status of Heavy Electrical Machinery Design, by F. D. Newbury, Westinghouse Electric & Mfg. Co. Motion picture, entitled "From Coal to Electricity," was shown. Joint with A. S. M. E. February 24. Attendance 50.

Detroit–Ann Arbor

Electricity in Modern Office Buildings, by Geo. Wagschal, Consulting Elec. Engr. February 28. Attendance 65.

Cincinnati

Early History of the Cincinnati Street Railway System, by Col. T. P. Schoepf, Consulting Traction Engr.; H. L. Swift, and F. W. Peters, General Electric Co. February 99. Atttendance 99.

Cleveland

Power-Plant Development, by C. F. Hirshfeld, Detroit Edison Co. Joint with A. S. M. E. February 16. Attendance 240.

Denver

Dinner and Social. February 14. Attendance 80.

Erie

Recent Developments in Aeroplane Engines, by A. Nott, Curtis Aeroplane Co. Illustrated with moving pictures and slides. February 14. Attendance 150.

Ithaca

Underground Cables and Dielectrics, by Herman Halperin, Commonwealth Edison Co. February 24. Attendance 42.

Kansas City

Electricity in Transportation, by R. H. Parker, General Electric Co. February 13. Attendance 50.

Los Angeles

Activities and Possibilities of Student Branches of the A. I. E. E., by Lester Bateman, student;

Study of Vocal Music by the Oscillograph Record, by James Henry and Russell Graves, students;

Study of a 250-Mile Artificial Transmission Line, by Lloyd Swedlund, student;

Measurement of Potential Across Separating Switch Contacts, by Hugh Hamilton, student, and

The Faradoid Effect for Insulators, by W. A. Lewis, student. G. H. Barnes, Chairman, Board of Governors, American Green Cross, spoke on the work of the American Green Cross and the need of reforestation. The meeting then adjourned to the 1,000,000-volt laboratory of California Institute of Technology, where a demonstration of high-voltage arcs was made. Joint meeting with University of Southern California and California Institute of Technology Branches. A dinner preceded the meeting. March 6. Attendance 272.

Louisville

Some Features in the Design of Insulators, by A. H. Burnham, Locke Insulator Corporation. February 14. Attendance 12.

Lynn

Inspection trip to the South Boston Dry Dock to inspect the airplane carrier *Lexington.* February 11. Attendance 210.

Problems and Results from Interconnection in the Southeastern States, by W. E. Mitchell, Georgia Power Co. Illustrated with slides. February 13. Attendance 90.

Mechanical Aspects of Supercharger Development, by S. R. Puffer, General Electric Co.;

Theoretical Aspects of Super charger, by C. W. Smith, General Electric Co., and

A New High-Temperature Thermocouple, by H. Abrams. Illustrated with slides and models. February 29. Attendance 40.

The National Park System, by Randall Jones. Ladies' Night. March 7. Attendance 850.

Madison

Latest Inventions of the Bell Telephone Laboratories, by S. P. Grace. A dinner preceded the meeting. February 10. Attendance 400.

Milwaukee

Detroit Edison Power-Plant Problems, by Alex Dow, President, Detroit Edison Co. A dinner preceded the meeting. February 15. Attendance 80.

Minnesota

Power-Factor Correction, by W. H. Feldmann, Electric Machinery Co., and

Static Condensers for Power-Factor Improvement, by A. P. Bordeau, Electric Machinery Co. February 2. Attendance 70.

Niagara Frontier

Latest Developments of Welding, by C. L. Ipsen, General Electric Co. Illustrated with slides. February 10. Attendance 125.

Oklahoma

Oil Field Electrification, by W. F. Barnes, Westinghouse Electric & Mfg. Co., and R. L. Middleton, General Electric Co. February 15. Attendance 107.

Philadelphia

Production and Utilization of High-Voltage X-Rays, by G. Failla. Illustrated with slides. A dinner preceded the meeting. February 13. Attendance 100.

Pittsburgh

The Engineer in Industry, by W. S. Rugg, Westinghouse Electric & Mfg. Co. Motion picture, entitled "White Coal," was shown. February 14. Attendance 180.

Pittsfield

The Personalities of Heaviside and Steinmetz, by Dr. E. J. Berg, Union University. February 21. Attendance 150.

Conditions in China, by Dr. Tehyi Hsieh. March 6. Attendance 500.

Portland

The Application of Research to the Problems of the Bell System, by Dr. E. B. Craft. January 18. Attendance 130.

New Rogue River Power Plant, by P. O. Crawford, California, Oregon Power Co. February 10. Attendance 120.

St. Louis

Social Meeting. February 15. Attendance 125.

San Francisco

Voltage and Power Factor Control of Interconnected Power Systems, by L. F. Blume, General Electric Co. Dinner preceded the meeting. February 24. Attendance 72.

Schenectady

Engineering Problems in the Development of State and National Parks, by Major W. A. Welch, Palisades Interstate Park Commission. February 24. Attendance 75.

What is Happening in Italy, by Dr. Vincenzo Nitti, lecturer. March 2. Attendance 300.

Seattle

Correction of Power Factor on the Distribution System, by W. S. Hill, Grays Harbor Railway and Light Co. February 21. Attendance 77.

Sharon

New Developments in Supervisory Control, by R. J. Wensley, Westinghouse Electric & Mfg. Co. Illustrated with slides. Demonstration of the Televox. February 7. Attendance 561.

Elements of Vector Analysis for the Mechanical and Electrical Engineer, by V. Karapetoff. In the evening Professor Karapetoff gave a piano lecture recital. February 25. Attendance 342.

Springfield

The Diesel-Electric Locomotive, by D. C. Hershberger, Westinghouse Electric & Mfg. Co. February 20. Attendance 57.

Syracuse

The Rising Tide of Radio, by Dr. Alfred Morton, Radio Corporation of America. February 27. Attendance 211.

Toledo

Recent Developments in Astronomy, by J. B. Brandenberry, Toledo University. February 24. Attendance 32.

Toronto

John Murphy, Dept. of Railways and Canals, Ottawa, gave a talk on his trip to Italy in 1924. January 27. Attendance 60.

Vancouver

Vector Diagrams, by Dr. H. Vickers, University of British Columbia. March 6. Attendance 24.

Worcester

System Stability, by H. R. Stewart, Westinghouse Electric & Mfg. Co. February 29. Attendance 45.

A. I. E. E. Student Activities

WHY STUDENT BRANCHES?

By M. P. Weinbach

Counselor, University of Missouri Branch

The fundamental answer to this question, "Why Student Branches?", was given twenty-six years ago by Dr. C. F. Scott when, in his inaugural address as President of the Institute, he said that "The electrical industry of the future depends upon the college student of today," and that "The principal purpose in bringing the work of the Institute to the student is to enable him to keep in touch with actual things, and give him an idea of the kinds of work which lie before him, and for which he is preparing."

What Dr. Scott said, twenty-six years ago, is just as true now as it was then. He said it then with the definite purpose in view of inducing the Institute to establish Student Branches in those technical schools of higher rank in which electrical engineering was taught. I repeat his words today when nearly a hundred Student Branches are definitely affiliated with our National Society, the American Institute of Electrical Engineers. The Institute, in carrying out the suggestion of Dr. Scott by providing for Student Branches, "self-exciting centers of electrical activity" as he called them, is now actually giving to students of electrical engineering the great opportunity of gaining a perspective of engineering, and of its manifold problems that cannot be obtained in routine class-room work.

It is generally admitted that all future progress in the application of the physical sciences to the needs or pleasures of man depends upon the young generation in the technical colleges. The fact is never disputed that to insure a continuous and unbroken progress, it is absolutely essential that this coming generation of young engineers enter the field of activity properly fitted for the work and for the responsibilities demanded by doing the work right.

It is also fully conceded that engineering colleges cannot, and are not prepared to, turn out fully equipped, experienced engineers, capable of handling projects or of solving engineering problems of any degree of magnitude. The time that the student can spend in school is too short, and, moreover, the means of giving practical experience is frequently not available. All that the college can do is to attempt to give the student a thorough understanding of the fundamental principles of electrical engineering and allied sciences, and some knowledge of various methods of dealing with and solving engineering problems, so he will be prepared, in some measure, to learn in an efficient manner the practical work after graduation.

The very nature of the professional work of the electrical engineer demands an intimate knowledge of the theory before he can appreciate the many special problems met with in the design and construction of electrical machinery, or in the generation, transmission, distribution and utilization of electrical energy. What is aimed at, in other words, in present engineering education, is primarily to give the student a good start, and instil in him the desire to learn and to continue to learn.

The A. I. E. E. Student Branch as an adjunct to an engineering college is, and should be, a most efficient means in realizing this program of educating the young engineer. It should help successfully in cultivating in the student the habit of reading current technical literature, in order that he may present either original, or abstracts of, technical papers at branch meetings, and take part in the discussion of such papers. It is through these essential activities of the Student Branch, that the "would be" electrical engineer should get acquainted with and obtain information on topics, problems, appliances, and methods, which, for lack of time, cannot be and, as a rule, are not touched upon in the class room.

Our social, industrial, and economic life is so complicated now that each individual human unit is an integral part of an organization with a definite function which must be performed right and in harmony with those of others. No engineering project of any magnitude can be carried out by a single individual. Such a project involves, generally, the originator of the idea; the designer and his staff; the constructor and his assistants; the operator and his helpers. Many interests are involved. There must be co-operation and adaptations to define conditions, industrial or commercial, in order that the ultimate and desired result may be attained. Where can the technical student, the would-be engineer, get the information he will need, when, out of college, he finds himself a working unit, however unimportant. in such an organization?

In the A. I. E. E. Branch meetings the technical student discovers that the engineer is not always surrounded by charts, graphs, slide rules, or tables of integrals, but is frequently engaged in managing, constructing, or directing, and has definite obligations and great responsibilities. The serious minded technical student soon finds that he must cultivate a sense of responsibility, and acquire the necessary characteristics upon which to build his future activities.

The A. I. E. E. Student Branch should be a most excellent laboratory in which the technical student learns of the qualifications he must acquire, not only to get a job, but to hold it, and grow with it. The A. I. E. E. Branch should promote a better and more sympathetic understanding of the men we work with, the value of co-operation and solidarity in a common undertaking. It is through the Institute Student Branch that the engineering student should get acquainted with practical view points, methods, thought, and spirit of the leading members of our profession. It brings the engineering student into contact with those who shape the sentiment and policies of the profession; it brings him into contact with the practical engineer.

One of the many personal characteristics of students in which the industries employing our graduates are most interested, is leadership ability. Look over carefully the application blanks of the General Electric Company and of the Westinghouse Electric and Manufacturing Company. They desire to know whether the young man they expect to employ has the intellectual qualities that would fit him, ultimately, for an executive; that would fit him to shoulder the burdens of responsible affairs; that would fit him to be resourceful and daring, and judicious; that would fit him to accomplish things. They want to know whether the student whom they expect to employ is original, thorough in his work, and endowed with that particular mental quality called initiative. Obviously, we cannot expect that all these characteristics will be possessed by all out students, or by any in a very marked degree. With some of these qualities we may be born, and all of them may be more or less cultivated and developed. With many of our students they are latent and must be stimulated, encouraged, and carefully nurtured.

Not only do the industries make a careful selection of the students who possess, in some degree, leadership qualifications, which I have just mentioned, but a mentally sound and ambitious student actually expects to be some day a leader in the profession, to direct larger operations, develop new enterprises, supervise large constructions, solve difficult problems, and decide important questions. To be sure, we teachers attempt to stimulate and encourage such dormant abilities as we may observe in our students, but we naturally expect the student himself to do his best toward their developemnt and growth.

The A. I. E. E. Student Branch is, to my mind, a most fit training field for the development of these qualities. By his participation in programs, the would-be electrical engineer learns to stand before an audience; learns to present convincingly, and concisely, and clearly his ideas without the usual self-conscious manner so often noticeable in our class-rooms. There, he has the opportunity to exercise his critical faculty and strength of character without restraint or embarrassment. At the A. I. E. E. Student Branch meetings the young technical student learns, not only of what is being done, but also, in some degree, how things are done. For, in the very nature of their organization, the A. I. E. E. Student Branches do, and should carry on, though in a smaller and quite restricted degree, activities similar in scope to those which the Institute as a whole is engaged in.

Even a casual scrutiny of the activities and achievements of the Institute, since its foundation, would reveal that the unparalleled advance in our profession, as viewed from every angle, is almost entirely due to the spirit of co-operation that the Institute fostered, stimulated, and encouraged, and which dominated it in all its activities. The Institute has given the electrical engineer ideals to strive for, and a code of ethics to abide by. It has not only promoted the interest of the profession, but greatly elevated its standard.

The A. I. E. E. Student Branch is the connecting link between the technical college and the profession. It is through the Student Branch that the student is given the opportunity to learn, not only of the function of the profession in its many and ever increasing ramifications, but its duties to society, its ethics, something of its past achievements, and established traditions. It is through the Institute Student Branch that the technical student, by his association with others, learns that to attain some degree of success he must think of himself as an integral part of the profession, as well as of the community that he is expected to serve; it is through his activities in the Branch that the student acquires that indefinable, but often intensely felt, something called professional or civic spirit.

The A. I. E. E. Student Branch brings about friendship among students whose interests are not only similar, but decidedly common. It brings about a closer contact between electrical engineering students of one institution and those of others, if not of the whole country, at least with those in the same Geographical District of the Institute. What other agency could have brought us together today to talk over matters of common interest, or to help one another by our individual experiences?

Why Student Branches? Why this definite and constructive policy on the part of the American Institute of Electrical Engineers to interest itself in the training of its future members through their enrolment while students, and the guiding of the functioning of the Student Branches? In the words of Dr. Scott, of twenty-six years ago, because "The electrical industry of the future depends upon the college student of today."

NORTH EASTERN DISTRICT TO HOLD STUDENT CONFERENCE AND CONVENTION

Extensive plans have been made for a conference on Student Activities and a Student Technical Session which are to be held on Friday morning May 11, 1928, in connection with the Regional Meeting of the North Eastern District (No. 1), at New Haven, Conn., May 9-12.

The conference will include a number of talks on various phases of Branch activities by students and faculty members, and a general discussion of student activities. About six papers on technical subjects will be presented by students in the technical session which will be held immediately after the Conference. A luncheon meeting of Counselors and Branch Chairmen will follow the technical session.

In planning the program for Friday and Saturday, the Committee has purposely made it possible for engineers and students to attend each other's technical sessions and to share in an inspection trip, with the hope that each group will learn more of what the other is doing.

CONFERENCE ON STUDENT ACTIVITIES IN DISTRICT NO. 6

The second Annual Conference on Student Activities of the North Central District No. 6 was held at the University of Nebraska, Lincoln, on March 2 and 3, 1928. Of the eight Branches in the District, six were represented by Counselors and Chairmen, and one by the Chairman only. Dean O. J. Ferguson, Vice-President, District No. 6, and Professor O. E. Edison, District Secretary, were present.

Friday Evening Session

The first session was held on Friday evening March 2nd, with Vice-President Ferguson presiding, and the following program was presented:

Address of Welcome, Professor V. L. Hollister, University of Nebraska.

Financing Branch Activities, Professor D. R. Jenkins, Counselor University of North Dakota Branch; J. A. Setter, Chairman University of Colorado Branch. G. K. Baker, Chairman University of Denver Branch.

General Discussion

Types of Programs Best Suited for Branch Meetings, Professor J. O. Kammerman, Counselor South Dakota State School of Mines Branch; Professor W. C. Du Vall, Counselor University of Colorado Branch; Alfred Botten, Chairman University of North Dakota Branch.

Saturday Morning Session

Vice-President Ferguson presided at this session also, and the program presented was as follows:

Student Original Papers for Branch Meetings, Professor R. E. Nyswander, Counselor, University of Denver Branch, (Read by Professor O. E. Edison); Professor B. B. Brackett, Counselor, University of South Dakota Branch; J. O. Yates, Chairman, University of Wyoming Branch; Lester Becker, Chairman, South Dakota State School of Mines Branch.

The Awarding of Regional Prizes for Branch Papers. Reading of statement on Regional Prizes in August 1927 Journal, by Lester Becker; Professor G. H. Sechrist, Counselor, University of Wyoming.

General Discussion

Mr. Setter reported that the University of Colorado Branch frequently serves refreshments after a meeting, and that this practise stimulates interest and attendance. The local dues were increased last year from $0.25 to $0.50 per quarter. He mentioned several college activities in which the Branch participates.

Mr. Baker discussed the various means of arousing interest among the students, the best methods of collecting dues or assessments, and the handling of expenditures by a definite plan or budget.

Professor Kammerman stated the chief purposes of the Student Branches, and said programs should be of such a nature as to attract the students, but must be instructive as well as entertaining.

Professor Du Vall said Branch Meetings should be inspirational and give the students a broad view of the electrical engineering profession, and that motion pictures should be used only to a very limited extent.

Mr. Groat emphasized the benefits students can receive by participating in the programs, and said the University of North Dakota Branch relies mainly upon talks by the juniors and seniors.

In his paper on *Students, Original Papers for Branch Meetings*, Professor Nyswander stated that his study of reports of Branch meetings in the Journal had indicated that a very small number of the student papers are based on original work. He thought reports or reviews of papers in the Journal and other publications by students an admirable form of Branch program.

Professor F. W. Norris, Counselor, University of Nebraska Branch, was elected to represent the District Committee on Student Activities at the Summer Convention which is to be held in Denver in June.

CONFERENCE ON STUDENT ACTIVITIES IN DISTRICT NO. 7

The first morning of the Regional Meeting of the South West District No. 7 held at St. Louis March 7-9, 1928, was devoted to a conference on Student Activities for which plans had been made under the leadership of Dean G. C. Shaad, Chairman of the District Committee on Student Activities, and Professor H. G. Hake, Chairman of the Counselors' Meeting Committee.

Dean Shaad presided, and the following program was presented:

Opening Remarks, A. E. Bettis, Vice-President, South West District, A. I. E. E.

Report on Conference on Student Activities at Detroit, Dean G. C. Shaad, Chairman District Committee on Student Activities.

Breakdown Tests of Sheet Dielectrics, R. L. Belshe and F. R. Small, Washington University Branch. (Presented by Mr. Small).

Why Student Branches?, Professor M. P. Weinbach, Counselor University of Missouri Branch; W. H. Mann, Jr., Chairman University of Arkansas Branch.

The More Attractive Meeting, R. D. Bradley, Chairman Kansas State College Branch.

Self-Government, Dick Mason, Chairman University of Oklahoma Branch.

Primary Allegiance, J. B. Robuck, Chairman University of Texas Branch.

Outside Activities, Benny Fonts, Chairman Oklahoma Agricultural and Mechanical College Branch.

For the Good of the Order, J. L. Pratt, Chairman Agricultural and Mechanical College of Texas Branch.

Early in the program, President Gherardi was introduced to the audience, and spoke briefly upon the great benefits to the Institute and to the individual members of the organization of Districts, Sections, and Branches, and emphasized the importance of bringing the electrical engineering students into close relations with the Institute. He said the students of today will be the backbone of the engineering organizations of the country ten years from now and that they will be the leaders in engineering work in 20 years.

Professor Weinbach's paper on "Why Student Branches?" is published in full in this department.

Speaking on the same subject, Mr. Mann said students can secure valuable training in leadership by participating in Branch activities and thus developing ability to speak well before a technical or non-technical audience. Two student talks are given at each meeting of the University of Arkansas Branch.

Mr. Bradley said each program of the Kansas State College Branch includes a technical talk and a talk on electrical current events by students. Talks on summer experiences have proven very successful. He discussed the various other activities of his Branch, and urged that more cooperation between Branches be developed.

Mr. Mason expressed his great appreciation of the willingness of the faculty members in electrical engineering at the University of Oklahoma to cooperate with the Branch.

In his paper on Primary Allegiance, Mr. Robuck named and discussed the principal benefits to be derived from Branch activities by the individual student, and said the Branch is the most important organization on the campus from the standpoint of electrical engineering students, as it brings together all such students with no reference to grades of scholarship. The Branch forms the beginning of a connection with the A. I. E. E. which will be increasingly helpful after graduation. Experience gained in the preparation, presentation, and discussion of papers and in dealing with others is very beneficial in later work. Branch papers can supplement the class work in a very helpful manner by bringing out many interesting facts that can be learned only by practical experience.

Mr. Fonts reported upon the outside activities engaged in by Branches in the District. Some of those mentioned were electrical shows, inspection trips, smokers, a watermelon feed, and an annual luncheon for seniors. The Missouri School of Mines Branch is planning to hold a bi-weekly luncheon with the young business men of Rolla who are interested in electrical developments.

Mr. Pratt emphasized the benefits to be derived from the A. I. E. E. in keeping in touch with progress in electrical engineering, and said Branch programs should be sufficiently attractive to secure good attendance, but must contain instructive material and not entertainment only.

Seven of the ten Branches in the District were represented by Counselors and Chairmen, and two others were represented by their Chairman. Dean G. C. Shaad was re-elected Chairman of the District Committee on Student Activities, and Counselor Delegate to the Summer Convention. Professor M. P. Weinbach was elected alternate delegate.

STUDENT CONVENTION AT LAFAYETTE COLLEGE

With the cooperation of the Lehigh Valley and Philadelphia Sections, the fourth annual Student Convention of the eastern part of District No. 2 was held at Lafayette College, Easton, Pennsylvania, on March 21, 1928.

The following papers were presented at the morning technical session:

Impedance Measurements on Loaded Telephone Cable, C. S. Thaeler, '28, Lehigh University.

Preliminary Tests of D-c. Excited Reactor, C. L. Haines, '28, Swarthmore College.

Symposium on Electric Welding, E. S. Dobson, '28, Lafayette College.

The papers contained much interesting material and were well presented.

After a buffet luncheon, four parties started on inspection trips as follows:

1. Ingersoll-Rand Company, Phillipsburg, N. J.
2. Lehigh Portland Cement Company, Sandt's Eddy, Pa.
3. Mack Printing Company, Easton, Pa.
4. R. & H. Simon Silk Company, Easton, Pa.

The Glendon Substation of the Metropolitan Edison Company was visited by a considerable number on the return trip from the four places named above.

Beginning at 4:30 p. m., there was an inspection of Lafayette College grounds and buildings, including the electrical engineering laboratory and a special exhibit of arc welding equipment.

A dinner was held in Brainerd Hall at Lafayette College.

At a joint meeting of the Student Branches and the Lehigh Valley and Philadelphia Sections, Dr. W. E. Wickenden, Director of Investigation, Society for the Promotion of Engineering Education, gave an address on the subject, *The Outlook for the Student Engineer.* It was illustrated with numerous lantern slides and was extremely interesting to all present.

The first and second prizes of $10.00 and $5.00 offered by the Lehigh Valley Section for the two best technical papers presented in the morning session, were awarded to C. S. Thaeler, Lehigh University, and E. S. Dobson, Lafayette College, respectively.

Students of the following schools cooperated in plans for the Convention: Delaware, Drexel, Haverford, Lafayette, Lehigh, Pennsylvania, Princeton, and Swarthmore.

BUCKNELL UNIVERSITY AND PENNSYLVANIA STATE COLLEGE BRANCHES HOLD JOINT MEETING

The Student Branches of Bucknell University and Pennsylvania State College held a joint meeting at Pennsylvania State

College on the afternoon and evening of March 7, 1928. About 70 students, including 22 from Bucknell University, attended.

The afternoon session was devoted to an inspection of the electrical laboratories of the Pennsylvania State College. At the evening session, Carl Dannerth, Chairman Pennsylvania State College Branch, presided, and the following program was presented:

Address of Welcome, R. L. Sockett, Dean of School of Engineering, Pennsylvania State College.

Relation between Case Hardening and Magnetic Properties, H. N. Matteson, '28, and F. W. Olshefsky, '28, Pennsylvania State College.

Local Central Office Control, G. B. Timm, '28, Chairman Bucknell University Branch.

Performance of Polyphase Watthour Meters, J. L. Wagner, '28, Pennsylvania State College.

The student papers named above were prepared from the results of original research work done by the authors. Members of both Branches showed great enthusiasm, and plans were made for a second joint meeting which will be held at Bucknell University in April.

STUDENT PROGRAM AT LOS ANGELES SECTION MEETING

The annual student meeting of the Los Angeles Section was held at the California Institute of Technology on the evening of March 6, 1928, with the Student Branches of that institution and the University of Southern California.

After a joint dinner, the following program was presented before an audience of 272:

The Activities and Possibilities of the Student Branches of the A. I. E. E., Lester Bateman, University of Southern California Branch.

Study of Vocal Music by the Oscillograph Record, James Henry and Russell Graves, University of Southern California Branch.

A Study of a 250-Mile Artificial Transmission Line, Lloyd Swedlund, California Institute of Technology Branch.

The Measurement of Potential Across Separating Switch Contacts, Hugh Hamilton, California Institute of Technology Branch.

The Faradoid Effect for Insulators, Wm. A. Lewis, California Institute of Technology Branch.

Mr. George H. Barnes, Chairman of the Board of Governors of the American Green Cross, gave a brief talk on the work of that organization and the need of reforestation.

Following the adjournment of the meeting, a demonstration of high-voltage arcs was given in the 1,000,000-volt laboratory of the California Institute of Technology, and Professor R. W. Sorensen described the latest developments in the vacuum switch.

BROWN ENGINEERING SOCIETY AFFILIATED WITH INSTITUTE

In 1926 the Board of Directors provided for the affiliation of general student engineering societies with the Institute by adopting Section 59A of the By-laws. The application of the Brown Engineering Society of Brown University, Providence, Rhode Island, for such affiliation was approved at a meeting of the Board of Directors held on February 16, 1928.

The principal purpose of the Institute in providing for affiliation of this type is to indicate clearly its willingness to cooperate with general student engineering societies in those institutions in which it is not deemed desirable to organize Student Branches. Members of such affiliated societies will be granted the privilege of subscribing for the JOURNAL at the reduced rate of $3.00 per year.

ELECTRICAL RECEPTION AT MONTANA STATE COLLEGE

The Montana State College Branch held an electrical reception on the evening of March 7, 1928. The twenty-two special exhibits prepared by the upper classmen included artificial lightning, a radio-controlled car, X-rays, and other instructive demonstrations of various types of electrical equipment. A continual performance was given between 7:30 and 10-30 p. m., and refreshments were served.

CAMP IN ADIRONDACKS ESTABLISHED BY CLARKSON COLLEGE STUDENTS

At the suggestion of Professor A. R. Powers, Counselor of Clarkson College of Technology Branch, members of the Branch decided to establish a camp on Big Simonds Pond near Tupper Lake, New York.

Under the supervision of the Camp Committee of the Branch, a site was purchased, and students erected a temporary building which will accommodate about twenty men. Provisions have been made for the erection of a permanent camp, and for individual camps on the property, which includes about one-half mile of water front and extends back to a distance of two to three hundred yards, and an island. The camp is intended for the use of all Clarkson students and former students, and will, it is hoped, bring about a closer relationship between students and alumni.

BRANCH MEETINGS

Armour Institute of Technology

Motion picture, entitled "Voices Across the Sea," was shown. January 27. Attendance 30.

Advances in Telephone Engineering, by Burke Smith, Transmission Engineer, Illinois Bell Telephone Co. Joint meeting with A. R. A. February 16. Attendance 40.

Alabama Polytechnic Institute

Present Situation of the Electrical Industry and Opportunities for Junior Engineers, by Professor W. W. Hill, Counselor. Discussion of plans for Engineers' Day. February 16. Attendance 53.

Impromptu talks by several students on subjects of interest. Announcement of plans for Engineers' Day. February 23. Attendance 53.

Talk on Arc Welding, by N. W. Geist, based upon his Summer work;

Creosoted Poles, by P. E. Sandlin, and

Summer Work with Westfield Steel Works, by H. Hickman. March 1. Attendance 52.

University of Arizona

Business Meeting. Professor J. C. Clark, Counselor, and G. T. Mitchell, Branch Chairman, reported upon the Pacific Coast Convention. October 1. Attendance 14.

Smoker. Talks by Professors J. C. Clark and W. M. Kellogg on summer experiences and inspection trips. October 17. Attendance 14.

The Seismograph, by Audley Sharpe, student. Social Meeting. Refreshments. November 21. Attendance 13.

Transatlantic Telephony, by H. S. Hamilton, American Telephone and Telegraph Co. December 13. Attendance 40.

Short talks by Professors Clark and Kellogg on A. I. E. E. and subsequent meetings of the Branch. Film, entitled "Yours to Command," was shown. A. B. Ellicock appointed Safety Representative. February 4. Attendance 7.

University of Arkansas

Electrical Opportunities in South and Central America, by Mr. Gooch, United Fruit Company. February 14. Attendance 15.

Brooklyn Polytechnic Institute

Western Electric Public Address System, by Mr. Caldwell, student; *Thermionic Voltmeter*, by Mr. Hudtwalker, student; *Measurement of Composite Current in Track Circuits*, by Mr. Kreutzer, student; *Laboratory Design*, by Mr. Brown, student; *Automobile Generator*, by Mr. Daniele, student; *Klydonograph*, by Mr. Atkin, student; *Electric Arcs*, by Mr. Brandler, student, and *Dial Telephone*, by Mr. Siegal, student. The purpose of the meeting was to select a student to represent the Branch at the N. Y. Section Student Convention in April. February 23. Attendance 60.

Measurement of Composite Current in Track Circuits, by Mr. Kreutzer, student; *Thermionic Voltmeter*, by Mr. Hudtwalker, student, and *Automobile Generator*, by Mr. Daniele, student. Judges had difficulty in deciding which students presented the best paper at the previous meeting so three of the contestants were invited to present their papers again. March 5. Attendance 75.

Bucknell University

Joint meeting with Penn. State College Branch. (See account elsewhere in Student Activities Dept.) March 7. Attendance 70.

California Institute of Technology

Safety, by E. W. Templin, Safety Representative. Announcement of joint meeting with the Los Angeles Section and University of Southern California Branch to be held on March 6, 1928. February 10. Attendance 14.

Inspection trip to Pasadena Power and Light Co. February 10. Attendance 18.

Mechanical Problems of the New Pasadena Steam Power Plant, by Mr. Hedrick, Pasadena Power and Light Dept. February 22. Attendance 23.

Opportunities with the Telephone Company, by Richard Hambrook, Southern California Telephone Co. February 28. Attendance 18.

University of California

Industrial Mobilization, by Major Pinger, Ordinance Unit, R. O. T. C. Illustrated. Joint meeting with A. S. M. E. Discussion of plans for Engineers' Day. Reports of officers and committees. February 8. Attendance 34.

Carnegie Institute of Technology

Lighting and Wiring from a Public Utility Point of View, by W. H. Horton, Jr., Asst. Commercial Mgr., West Penn Power Co., and

Engineering Progress during 1927, by J. H. Ferrick and G. H. Ikola, students. J. H. Ferrick elected Secretary. February 14. Attendance 23.

Clarkson College of Technology

Photography, by W. A. Dart, Asst. Prof. Discussion of the proposed New York inspection trip preceding the New Haven Convention. February 16. Attendance 30.

Clemson College

America's Greatest Water-Wheel, by E. S. Murrah;

Some Transmission Line Fundamentals, by M. A. Jones;

Screen Grid Radio Tube, by C. R. Martin, and

Current Events, by R. C. Carter. February 9. Attendance 18.

Colorado Agricultural College

The Application of the New Shield Grid Tube to Radio, by Prof. H. G. Jordan, Counselor. February 13. Attendance 14.

University of Colorado

A film, entitled "Through the Switchboard," was shown. February 7. Attendance 50.

Cooper Union

Television, by R. A. Deller, Bell Telephone Laboratories, Inc. Slides and demonstration. February 15. Attendance 82.

University of Denver

Properties and Uses of Fused Quartz, by B. J. Rowan, General Electric Co. R. H. Owen, Chief Operating Engr., Broadcasting Station KOA, demonstrated the operation and uses of photo-electric cells. Slides on recent developments of the General Electric Co. W. B. Clark of that Company demonstrated new light produced by a mercury vapor tube and a neon tube. February 10. Attendance 160.

Duke University

Description of new engineering courses leading to the degree of B. S. in E. E. read and discussed. February 29. Attendance 16.

University of Florida

The Engineer and the Electric Utility, by R. W. Cryder, Vice-President, Florida Power Corp. February 6. Attendance 35.

University of Idaho

Fundamental Conceptions of Radio, by T. L. Styner, student. Appointment of committees. Discussion of plans for Engineers' Day. February 15. Attendance 21.

Iowa State College

Discussion of plans for increasing the interest in A. I. E. E. February 28. Attendance 17.

Transmission of Pictures by Wire, by C. T. Schrage, American Tel. & Tel. Co. March 7. Attendance 26.

State University of Iowa

Some Engineering Developments of 1927, by D. L. Thomas;

New Developments in Radio Vacuum Tubes, by M. W. Tilden, and

Radio Aerials, by J. S. Beck. Report on A. I. E. E. Regional Meeting in Chicago. December 14. Attendance 29.

Film, entitled "Nature's Frozen Credits," was shown. January 4. Attendance 29.

Television, by J. O. Perrine, Bell Telephone Laboratories, Inc. Joint meeting with A. S. C. E. and A. S. M. E. Branches. January 11. Attendance 210.

Inland Waterways, by H. E. Seeman, Chicago & Northwestern Railway Co. Branch attended a meeting of Student Chapter of A. S. C. E. January 18. Attendance 60.

Motion picture, entitled "The General Motors Proving Ground," was shown with Student Branch A. S. M. E. February 1. Attendance 50.

Radio and Wireless, by N. R. Rector, and

Illumination of Flying Fields, by W. E. Christiansen. February 8. Attendance 27.

Ground Detectors, by L. L. Heskett, and

Electric Welding, by J. T. Jones. February 22. Attendance 27.

Vibrations in a 25,000-Kw. Turbine, by J. L. Jordan;

The Boulder Dam Project, by G. R. Parizek, and

Energy Interchanges on the Pacific Coast, by D. L. Thomas. February 29. Attendance 27.

Kansas State College

Discussion of final plans for Engineering Open House. Film, entitled, "Cuba," was shown. February 6. Attendance 91.

Film, entitled "Power Transformers," was shown. February 20. Attendance 77.

Lewis Institute of Technology

Committee appointed to give reports on Safety. A. Gaimari appointed Safety Representative. February 21. Attendance 40.

Motion picture, entitled "Wizardy of Wireless," was shown. February 28. Attendance 87.

The Responsibility of the Student, the College and the Employer in the Development of the Student, by H. W. Bang, (Alumnus), Vice-President, Illinois Bell Telephone Co. March 6. Attendance 180.

Lehigh University

The Development of Railroads, by J. G. Bent, Jr., student, and

Motor Requirements in Industry, by C. N. Johnson, Mgr., Engineering Division, Westinghouse Elec. & Mfg. Co., Philadelphia. Refreshments served after the evening's papers, and several short informal speeches made by members of the faculty and visitors. February 24. Attendance 85.

University of Maine

Modern Trends in Engineering, by H. W. Coffin, Operating Engr., Bangor Hydro-Electric Co. Dean Paul Cloke, College of Technology and Prof. W. E. Barrows, Jr., Counselor, spoke briefly on the Winter Convention of the A. I. E. E. Motion pictures on "Story of Power" and "Water Power" were shown. February 22. Attendance 25.

History of Transportation, by Prof. A. S. Hill, and

Railway Drive, by N. J. Timull, student. Film, entitled "King of the Rails." March 7. Attendance 28.

Marquette University

Engineering in Norway, by Andrew Benton, T. M. E. R. & L. Co. The following officers were elected: President, P. C. Neumann; Vice-President, H. Haase; Secretary, W. E. Schmitz, and Treasurer, A. Lutropp. These men will take office in July 1928. March 8. Attendance 42.

Massachusetts Institute of Technology

Films, entitled "The Making of Mazda Lamps," and "The Electrical Giant," were shown. Discussion of papers to be presented at the District Student Convention and at Branch meetings. February 15. Attendance 50.

Michigan State College

H. D. Sanborn, Chicago Office, General Electric Co., gave a talk on atomic theory and vacuum tubes. Motion picture, entitled "Beyond the Microscope," was shown. February 14. Attendance 65.

University of Michigan

Electricity and the Automobile, by John Hunt, Head of Electrical Division, The General Motors Corp. The Branch voted to approve the formation of an Engineering Council. February 15. Attendance 54.

Engineering School of Milwaukee

Lighting and Its Relation to High-Voltage Transmission, by W. S. Wilder, Milwaukee Electric Railway and Light Co. Adney Wyeth appointed Secretary. March 2. Attendance 250.

Mississippi A. & M. College

Business Meeting. Prof. L. L. Patterson, Counselor, read several letters he had received relating to A. I. E. E. work. L. H. Calloway elected Safety Representative. The Secretary reported on the finances of the Branch. February 16. Attendance 20.

Development of Automatic Switching, by R. S. Kersh, student;

Enlarging a Substation, by E. H. Toney, student, and

The Mercury Arc Rectifier, by A. T. Holloway, student. March 8. Attendance 38.

University of Missouri

Carrier Currents in Telephony, by G. E. Buck, General Electric Co. March 2. Attendance 65.

Montana State College

Electrical Reception. See Report elsewhere in Student Activities dept. March 7. Attendance 422.

University of Nevada

D. I. Cone, Transmission and Protection Engr., Pacific Tel. & Tel. Co., gave a talk on the policies of his company and the opportunities for students offered by it, followed by a talk on "The Transatlantic Telephone." Slides and diagrams. February 1. Attendance 35.

Newark College of Engineering

Sounds That Burn, by W. B. Morningstern, Jr., student;

Novel Uses for Electricity, by W. K. Baer, student, and

Measuring a Billionth of an Inch, by J. K. Dennis, student. March 5. Attendance 16.

University of New Hampshire

Electrolysis, by W. S. Balch, student. February 13. Attendance 37.

Life of Oliver Heaviside, by Messrs. Langford and Morreels;

Insulation Testing, by Messrs. Learned and Sargent, and

Application of Safety Requirements to the Electrical Industry, by Mr. Nulsen. February 20. Attendance 35.

America's Largest Water-Wheel, by E. B. Moore and L. C. Simpson;

Curbing the Mississippi, by L. Morrissette and C. E. Turschman, and

Weighing by Radio, by N. Pierce and E. L. St. Clair. February 27. Attendance 36.

Instruments, by Mr. Corby, Weston Elec'l. Instrument Corp. Illustrated with motion pictures. March 5. Attendance 38.

College of the City of New York

Business Meeting. Reports of officers and Student Convention Committee. Discussion of programs for coming term. The following officers were elected: Chairman, J. Leipziger; Secretary, A. H. Rapport; Treasurer, Walter Broleen; Librarian, Edw. Grossman. February 16. Attendance 20.

Televox, by R. J. Wensley, Westinghouse Elec. & Mfg. Co. Demonstration. February 20. Attendance 72.

Cold Swaging, Its Applications and Advantages, by G. H. Schneider, Torrington Company. Illustrated by specimens and demonstration. Joint meeting of A. I. E. E. and A. S. M. E. February 23. Attendance 41.

Inspection trip to Roxy Theatre. February 28. Attendance 36.

The Gas Refrigerator, by Dr. C. A. Lunn, Chief Chemist, Consolidated Gas Co. Joint meeting of all engineering societies at C. C. N. Y. Motion picture, entitled "The Modern Gas Plant and Its Service," was shown. March 1. Attendance 68.

New York University

The Televox, by R. J. Wensley, Westinghouse Elec. & Mfg. Co., Demonstrations were given with the talk. February 23. Attendance 625.

Steam vs. Electric Railways, by Joseph Johanessen, student, and

Electrical Railway Systems, by Vincent E. Reilly, student. March 8. Attendance 31.

North Carolina State College

Outline of Student Work with the General Electric Company, by A. W. Hamrick. February 21. Attendance 50.

University of North Carolina

Potheads, by C. R. Jones. He also told of his experiences with the Tidewater Power Co., and

Rural Distribution Extensions, by W. E. Stewart. Program Committee appointed. February 23. Attendance 23.

Northeastern University

Electrical Engineering, by A. H. Sweetnam, Supt., Elec. Engg. Dept., Edison Electric Illum. Co. of Boston. February 14. Attendance 122.

Inspection trip to the Hygrade Lamp Co., Salem, Mass. February 17. Attendance 25.

University of Notre Dame

A Mathematical Analysis of Oscillating Circuits, by Richard Greene, student, and

An Original Theory of the Phenomena of Thunder Storms, by Professor Hull. February 13. Attendance 60.

Story of the Life and Works of Maxwell, by Ralph Garza, and

The Field of Mathematics, by Dr. J. A. Caparo, Counselor. Refreshments were served. February 27. Attendance 53.

Mercury Arc Rectifiers on the South Shore Line, by Mr. Ludden, Asst. Elec. Engr. Mr. Kelly, Asst. Engr. of Ways and Structures, of the same company, gave a brief description of the manner in which any addition is made to the line. March 5. Attendance 66.

Television, by R. A. Deller, Bell Telephone Laboratories, Inc. Dr. J. A. Caparo, Counselor, gave a brief outline of the development of television. March 9. Attendance 96.

Oklahoma A. & M. College

The Advancement of Oil Field Electrification in Recent Years, by Prof. Edwin Kurtz, Counselor;

Oil Field Electrification in General, by W. F. Barnes, Mgr. of Tulsa Office, Westinghouse Elec. & Mfg. Co.;

Oil Field Electrification, by R. L. Middleton, Oil Field Specialist, General Electric Co., Tulsa. Entertainment and refreshments. February 15. Attendance 100.

University of Oklahoma

Safety, and Accident Prevention, by Mr. Steel, Oklahoma Gas and Electric Co.; and Mr. Butler, and

Demonstration of Resuscitation, by Mr. Carr, Chief Electrician of Shawnee. Picture, entitled "The Story of Lead Smelting," was shown. Joint meeting with A. S. C. E., A. S. M. E., and Pick and Hammer. February 23. Attendance 27.

Business Meeting. March 6. Attendance 21.

Oregon State College

Electric Transmission Stability, by V. W. Wilfley, Westinghouse Electric & Mfg. Co. Refreshments served. February 14. Attendance 110.

Pennsylvania State College

The Vacuum Tube as a Detector and Amplifier, by E. F. Bond, student, and

Experiences of a Commercial Radio Operator, by F. M. Gager, student. Motion pictures, entitled respectively "Operation of A. C. and D. C. Instruments," and "Construction and Operation of Induction Regulators," were shown. February 15. Attendance 77.

Future Developments in Electrical Engineering, by Dr. W. P. Davey, Physics Dept. February 28. Attendance 62.

Joint meeting with Bucknell University Branch. See account elsewhere in Student Activities Dept. March 7. Attendance 69.

University of Pittsburgh

Rectifiers, by J. J. Crawford, student, and

Some Interesting Engineering Experiences, by Mr. Carl, Westinghouse Electric & Mfg. Co. February 17. Attendance 44.

Functions of the Intelligence Department in the U. S. Army during the World War, by C. Cabeny, student. February 24. Attendance 43.

Princeton University

The History of the Incandescent Lamp, by Henry Schroeder, Commercial Engr., Edison Lamp Works, General Electric Co. Illustrated with slides. February 16. Attendance 12.

Purdue University

Watthour Meters, by F. L. Pavey, Duncan Electric and Mfg. Co., and

Talk on A. I. E. E., by R. C. Fryer, Chairman, Cincinnati Section, A. I. E. E. Meeting was held in connection with Meter Convention of the University. December 6. Attendance 80.

The Hydroelectric Development on the Ohio River at Louisville, Ky., by N. C. Pearcy, Louisville Lt. & Pr. Co. Moving pictures of the construction of the dam and power house were shown.

Practical Demonstration of the Schaefer Method of Resuscitation, by C. W. Bennett, Northern Indiana Public Service Co. Motion picture, entitled "Story of Asbestos," was shown. Joint meeting. February 21. Attendance 75.

Rensselaer Polytechnic Institute

New Zealand, by Dr. M. A. Hunter, Prof. of Electro-Chemistry. Motion picture, entitled "From Coal to Electricity," was shown.

Stone and Webster, the Company, its Methods, Growth and Accomplishments, by Dr. W. L. Robb, Head, Dept. of Elec. Engg. February 14. Attendance 140.

Rhode Island State College

Synchronous Converters, by V. E. Murphy, student. Slides.

Frequency Chargers, by W. H. Cook, student. January 21. Attendance 18.

Silas P. Washington, '28, gave a talk on his work at Iowa State College and with the Boston Elevated Railway. January 27. Attendance 19.

The Quest of the Unknown, by Prof. H. B. Smith, Worcester Polytechnic Institute. Slides. February 4. Attendance 75.

Radio Development in 1927, by C. F. Scott, '28. February 17. Attendance 21.

Rutgers University

Operation of Doors by Electricity, by C. G. Walton, '29, and

Automatic Switching, by A. Pietschmann, '28. February 13. Attendance 9.

University of Santa Clara

Electric Drive in Cement Plants, by C. A. Binns, General Electric Co. February 14. Attendance 84.

Inspection trip to the Pacific Portland Cement Company's Plant at Redwood City, Cal. February 21. Attendance 55.

South Dakota State School of Mines

Business Meeting. January 19. Attendance 29.

Annual A. I. E. E. Frolic to welcome Freshman and Sophomore students. Prof. J. O. Kammerman, Counselor, welcomed the new students and explained work in elec. engg. both in school and outside. Prof. E. E. Clark related experiences in the Electrical Engineering Department in its early years. Refreshments were served. January 20. Attendance 64.

A talk was given by Irving Dier, Northwestern Bell Telephone Co., on his work last Summer in preparation for the coming of President Coolidge and his party to the Black Hills. On a vote by ballot L. M. Becker was elected Chairman. February 3. Attendance 23.

University of South Dakota

Niagara Falls and Its Hydroelectric Plants, by C. R. Cantonwine, Chairman. Illustrated.

Electrical Developments and Possibilities in Japan, by Orla Bendixen. February 22. Attendance 9.

Business Meeting. A report on the Conference on Student Activities at Lincoln, Neb., on March 2 and 3 was given by C. R. Cantonwine, Chairman, and a general discussion followed. March 7. Attendance 12.

University of Southern California

Advantages and Purposes of the Student Branch at the University, by Lester Bateman, Chairman. Prof. P. S. Biegler, Counselor welcomed the freshmen and gave a short talk on prospects for a school of engineering and a new engineering building. February 9. Attendance 53.

Stanford University

What the Telephone Company Wants in the Young Engineer, by Mr. Judson and Mr. Geminer, Pacific Tel. & Tel. Co. February 15. Attendance 29.

University of Texas

Business Meeting. The following officers were elected: President, J. B. Robuck; Vice-President, M. R. Chamberlain; Secretary-Treasurer, J. F. Hinton; Corresponding Secretary, G. A. Toepperwein. February 7. Attendance 10.

Lightning Arresters, by Mr. Pingree, Dallas General Electric Co. Illustrated with slides. Short business session. February 23. Attendance 28.

University of Utah

Motion picture, entitled "Pavement Construction," was shown. February 14. Attendance 25.

High-Temperature Insulation, by D. K. Brake, student. Illustrated. Joint meeting with A. S. M. E. Chapter. February 21. Attendance 23.

Virginia Military Institute

Electrolytic Rectifier, by R. L. Downey;

Electrical Control of the Yacht Fan Kwai, by G. Shields, and

Installation of the New Equipment for Our Laboratory, by D. N. Higgens. February 23. Attendance 35.

Motion pictures on induction regulators and a railroad substation were shown. March 9. Attendance 41.

Virginia Polytechnic Institute

Electric Reproduction in the Phonograph, by R. Marchant, student;

Radio Batteries, by J. P. Shanklin, student, and

Manufacture of Turbo Alternator Coils, by E. A. Williams, student. February 8. Attendance 33.

Automobile Ignition Systems, by Prof. D. S. Heitsher, Automotive Engineering. February 20. Attendance 40.

The History and Development of the Atlantic Cable, by A. J. Mundt, Western Union Telegraph Co. February 24. Attendance 30.

University of Washington

Quick Response Excitation, by R. C. Willman, student. February 10. Attendance 21.

Television Apparatus, by L. Palmer, student. Prof. G. L. Hoard, Counselor, discussed plans for Open House. February 17. Attendance 14.

Location of Ships by Radio, by K. M. Durkee, student. E. D. Engel was appointed Safety Representative. Discussion of plans for Open House. February 24. Attendance 19.

The New Cushman Power Project, by A. F. Darland, Tacoma Light Co. March 2. Attendance 42.

West Virginia University

Triumphs of Radio, by E. W. Conway; *The Nation's Greatest Ships*, by M. Hooker; *Telephone Developments*, by D. Akins; *Steel Cored Aluminum Conductors*, by R. I. Boone; *Central Station Service*, by C. L. Parks; *How to Install a Telephone*, by S. C. Hill, and *Development of Lighting Industry in 1927*, by G. I. Burner. February 17. Attendance 32.

Electrical Insulating Oils, by M. C. Clark; *Basic Methods of Phototelegraphy*, by T. R. Cooper; *Steel Core Aluminum Conductors*, by F. D. McGinnis; *Hollow Spun Concrete Poles*, by G. E. Phillips; *A New Type of Turbo-generator Insulation*, by B. J. Paladino;

Stabilization of Electrical Refrigeration, by W. T. Myers, and

Easy-Made Tester for High-Voltage Testing, by A. L. Lindlay. February 24. Attendance 33.

University of Wyoming

Transatlantic Telephony, by L. R. Probst, Mountain States Tel. & Tel. Co. Illustrated with slides. February 21. Attendance 15.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES FEBRUARY 1-29, 1928

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

Die Abwarmetechnik, Bd. 1; Grundlagen. By Hans Balcke. Mün. u. Ber., R. Oldenbourg, 1928. 290 pp., illus., diagrs., tables, 9 x 6 in., cloth. 15.-r. m.

The first volume of a three-volume work upon waste-heat engineering. It discusses first the sources of waste heat, including exhaust steam, flue gases, condensed steam, cooling water, and excess electrical energy. It then takes up the principal elements of plants for utilizing waste heat and considers in detail the construction, use and efficiency of each.

Baustoffverarbeitung und Baustellenprufung des Betons.

By A. Kleinlogel. Ber. u. Lpz., Walter de Gruyter & Co., 1927. 106 pp., illus., diagrs., tables, 6 x 4 in., linen. 1,50 r. m.

This little book recognizes the fact that the soundness of concrete structures is largely dependent upon the care and workmanship of the builder, and that good design and careful standardization of materials will not alone insure good results. It is intended as a guide to superintendents of construction and contractors, and deals briefly with the testing of materials, methods of placing concrete and the testing of finished work.

Coal Miners' Pocketbook. Edited by E. N. Zern. 12th edition. N. Y., McGraw-Hill Book Co., 1928. 1273 pp., illus., diagrs., tables, 7 x 4 in., fabrikoid. $6.00.

The twelfth edition of this well-known reference book has been thoroughly revised, it is stated, and enlarged by the addition of one hundred pages of new matter. New sections have been added, treating of loading and conveying machinery, lubrication, and mine drainage and pumping. The material has been rearranged to facilitate quick consultation.

Construction Job Management.

By Charles F. Dingman. N. Y., McGraw-Hill Book Co., 1928. 220 pp., illus., diagrs., tables, 7 x 4 in., fabrikoid. $2.50.

Aims to place before the builder, particularly the inexperienced builder, a knowledge of the most effective ways of handling the several branches of building construction and of coordinating the work of the various trades employed. The chapters deal successively with the preparatory work, equipment, directing the work, organizing, handling masonry work, fireproof construction, plastering, and carpentry, and relations with subcontractors. Much practical advice is condensed into small space.

Hamilton Aerial Map of Manhattan. N. Y., Hamilton Aerial Map, 1927. Size of sheet 32 x 34. Complete with Binder, $55.00, plus service feature to Atlas owners, $1.00 per duplicate sheet. (For small area of the Island only, a pocket edition is published of one sheet for $3.00.)

This aerial map will cover Manhattan Island on a scale of 200 feet to the inch. Fourteen sheets have been published, extending from the Battery to Fifty-ninth Street, and the remaining seventeen are being prepared.

The map is printed from aerial photographs by a process which gives very clear reproductions. Street names have been inserted and a street index is provided. Street numbers are also indicated. The publication is available complete in a loose-leaf binder, or single sheets may be had in pocket cases.

Highway Engineering.

By John H. Bateman. N. Y., John Wiley & Sons, 1928. 418 pp., illus., tables, 9 x 6 in., cloth. $4.00.

A textbook for an undergraduate course in the subject. Aims to present the fundamental theory with comprehensive descriptions of present practice. Discusses successively the economics, financing, location, design, construction, maintenance, and operation of highways.

Interaction of Pure Scientific Research and Electrical Engineering Practice.

By J. A. Fleming. Lond., Constable & Co., 1927. 235 pp., illus., diagrs., 9 x 6 in., cloth. 15s.

Contains the substance of a course of lectures given in 1926 at the Institution of Electrical Engineers. The underlying purpose is to show the manner in which the electrical industry is based on, and advanced by, pure scientific research, and also the manner in which technology repays pure science by providing new materials and appliances, or larger opportunities for experiment. The author does this by discussing certain departments of electrical engineering and showing how technical advances in them have been due to scientific investigations undertaken in a disinterested spirit.

Jahrbuch 1927, der Deutschen Versuchsanstalt für Luftfahrt E. V., Berlin-Adlershof. Mün. u. Ber., R. Oldenbourg, 1927. 151 pp., illus., diagrs., tables, 12 x 9 in., cloth. 13.-r. m.

This volume contains the official report of the Versuchsanstalt for the year 1926-7, and twenty-one reports on investigations carried out under its auspices. These included tests of materials used in aircraft, methods of construction, studies of theoretical questions, etc.

JOURNAL OF THE ROYAL TECHNICAL COLLEGE, Glasgow. No. 4, December 1927. Glasgow (142 W. Nile St.) Royal Technical College, 1927. 128 pp., illus., diagrs., tables, 10 x 7 in., paper. 10s 6d.

This paper-bound book brings together thirteen papers upon researches carried on at the College. The researches are in the fields of electrical engineering, civil engineering, chemistry, metallurgy and mechanical engineering.

KOKEREI und GASWERKSOFEN.

By L. Litinsky. (Kohle, Koks, Teer, v. 17). Halle (Saale), Wilhelm Knapp, 1928. 336 pp., illus., diagrs., tables, 9 x 6 in., paper. 22,80 r. m.

This monograph treats exhaustively of coke ovens, and retorts and furnaces for generating fuel gas. The construction, output, heat economy, structural materials, etc., of these furnaces are discussed from an engineering point of view by an engineer who has specialized in this field and who here endeavors to discuss all questions that arise concerning furnaces for the distillation of coal. The volume forms part of an extensive series upon the mining and utilization of fuel.

THE MAKING OF A CHEMICAL; a guide to works practise.

By E. D. Lewis and George King. N. Y., John Wiley & Sons, 1927. 288 pp., illus., 9 x 6 in., cloth. $4.00.

This is an unusual book. It aims to be a guide to the young chemist who is entering a chemical works with the intention of devoting his life to manufacturing, and to accomplish this aim it puts before him a picture of works practise and works conditions based on experience.

After an introductory section on the preparation of the chemist, the book discusses the various stages through which a process passes in its development from the laboratory to its commercial form, manufacturing and selling costs, suitable materials for plant use and the works equivalents of laboratory apparatus. Throughout there is emphasis upon economics.

The book will prove helpful to every chemist confused by transfer from the laboratory to the factory.

NEW TOWNS FOR OLD.

By John Nolen. Bost., Marshall Jones Company, 1927. 177 pp., illus., 8 x 6 in., cloth. $3.00.

Mr. Nolen has here brought together some representative examples of civic improvement which have actually been carried out. The examples show how old industrial towns have been improved, how industrial towns have been built to order and how residential suburbs of a high class have been made attractive. The book supplements treatises on town planning by providing concrete examples of ways in which modern communities have combined convenience, permanence and beauty.

PERMANENT-WAY MATERIAL PLATE-LAYING AND POINTS AND CROSSINGS.

By W. H. Cole. 9th edition, revised by Gordon Hearn. Lond., E. & F. N. Spon, 1928. 245 pp., diagrs., tables, 7 x 5 in., cloth. 12/6.

A standard English book on railroad track and trackwork, treating of track standards, rails and accessories, track construction, track maintenance, switches and crossings, and signaling and interlocking. This edition covers both English and American practise, it is stated, and gives the standard types of switches and crossings recently designed in England.

PRINCIPLES OF HIGHWAY ENGINEERING.

By Carroll Carson Wiley. N. Y., McGraw-Hill Book Co., 1928. 510 pp., illus., tables, 9 x 6 in., cloth. $4.00.

In preparing this book, the aim has been to select, from the great mass of available material on road building, what will set forth or illustrate the various principles and practises in a manner and to the extent that the college student of highway engineering can absorb them in the available time. The book seems well adapted for use by the beginner and may also be useful as a reference book. The text is clear and concise and the illustrations are excellent.

PROTECTIVE METALLIC COATINGS.

By Henry S. Rawdon. N. Y., Chemical Catalog Co., 1928. (Amer. Chemical Society. Monograph series). 277 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.50.

This monograph is a summary of our knowledge of the subject, prepared by an experienced metallurgist. Within convenient limits, it discusses the various methods of coating by alloying, electroplating, metal spraying, or chemical treatment, giving the characteristics and properties of each. The various commercial coatings are then considered, chapters being devoted to the use of zinc, tin, copper, nickel, chromium, cobalt, lead, cadmium, aluminum, gold and silver. Methods of testing are finally discussed. A good bibliography is given. The treatment is principally directed to the value of coatings as preventives of corrosion.

RADIO ENGINEERING PRINCIPLES.

By Henri Lauer and Harry L. Brown. 2nd edition. N. Y., McGraw-Hill Book Co., 1928. 301 pp., diagrs., 9 x 6 in., cloth. $3.50.

The object of the authors has been to discuss thoroughly the principles of radio, from the engineering point of view, and to give the general means of utilizing them, so that they may be applied to any specific apparatus. Most of the book is devoted to a study of the characteristics and use of the three-electrode vacuum tube.

The new edition follows the plan of the preceding one but has been revised and extended to cover later developments.

SPHERICAL HARMONICS.

By T. M. MacRobert. N. Y., E. P. Dutton & Co., 1927. 302 pp., 9 x 6 in., cloth. $4.50.

This book aims to provide a text on the elements of the theory of Fourier series, Bessel functions, and spherical harmonics, with their applications to mathematical physics, so far as this can be done without using the method of contour integration.

THEORIE DER WECHSELSTROMUBERTRAGUNG.

By Hans Grünholz. Berlin, Julius Springer, 1928. 222 pp., diagrs., tables, 11 x 8 in., boards.

The author treats of the laws governing the transmission of power by alternating currents, and illustrates the application of the theory which he develops to the calculation and control of transmission phenomena in long a-c. transmission lines. The treatment is geometrical. A large number of circle diagrams, for the most part new, are given. The book is intended to give the engineer a rapid, exact method for practical use.

THEORY OF STRUCTURES.

By Charles M. Spofford. 3d edition. N. Y., McGraw-Hill Book Co., 1928. 587 pp., diagrs., tables, 9 x 6 in., cloth. $6.00.

Aims to present the fundamental theories underlying the design of engineering structures in a thorough, logical manner, and to illustrate their application by numerous examples. The subject-matter deals almost entirely with statically determined structures, but the approximate methods commonly used for the more usual types of indeterminate structures are also given. Some amplifications and rearrangements have been made in this edition and chapters on space framework and on frameworks of high buildings have been added.

WIRELESS PRINCIPLES AND PRACTISE.

By L. S. Palmer. N. Y., Longmans, Green & Co., 1928. 504 pp., illus., diagrs., tables, 9 x 6 in., cloth. $7.00.

This textbook is intended for the electrical engineer who wishes to become conversant with the high frequency aspects of alternating currents as applied in radio. The treatment is comprehensive and some consideration is given to almost every branch of the subject. Useful bibliographies accompany each chapter.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.
53 West Jackson Blvd., Room 1736, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 West 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription rate of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary; temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ENGINEER, to take over line of carbon products in New York territory. Headquarters, Pennsylvania. Apply by letter. X-3007-C.

ELECTRICAL DESIGN ENGINEER, with mature judgment, for manufacturer of X-ray and medical apparatus. Must be thoroughly competent to undertake basic new design work in this field and must have originality and sufficient executive ability to get things done. Apply by letter. Opportunity. Salary about $3600 a year to start. X-3403-C.

GRADUATE ENGINEER, with general engineering experience related to industrial power applications, and specific experience in sale of power for public utility. Apply by letter. Location, Michigan. X-3882-C.

MEN AVAILABLE

EXPORT SALES ENGINEER, 29, married, five years residence Europe and Far East, seeks position as manager or assistant in export department. Willing to make short trips abroad. Knows principal languages. Graduate Massachusetts Institute of Technology, electrical engineering. Successful sales and engineering record. C-4204.

SUPERINTENDENT OF CONSTRUCTION OR MAINTENANCE, 40, married; electrical and mechanical engineer; desires new connection as superintendent of construction or maintenance engineer with power company or industrial plant. Fifteen years' experience steam, hydro, Diesel. Specialize High Volttage Transformers, switch gear installation and switch boards. Invite correspondence. Location, British Columbia. Pacific Northwest, South. C-4169-82-C-1 SAN FRANCISCO.

GRADUATE ELECTRICAL AND COMMERCIAL ENGINEER, 26, single, Carnegie Institute of Technology, 1926; General Electric Test Course; Electrical development work, construction, maintenance, retail selling. Available on short notice. Desires permanent position. Location, New York, Philadelphia, Cleveland. C-3476.

ELECTRICAL ENGINEER, graduate, 26, married. 1½ years on General Electric Test in Schenectady. 1½ years as Power Engineer and one year as Distribution Engineer with public utility company, now occupied as Distribution Engineer. Desires position where there is chance for advancement. C-4171.

ELECTRICAL DESIGNING ENGINEER with broad experience in design and re-design of high- and low-voltage substations and underground systems. Thoroughly familiar with power plant auxiliary equipment, specifications, and estimates. C-4170.

GRADUATE ELECTRICAL ENGINEER, 39, married; 2½ years General Electric Test; 15 years as assistant to Electrical Engineer and General Foreman of Electrical Department for large Anthracite Coal Company. B-3554.

ELECTRICAL AND MECHANICAL ENGINEER, graduate, 26, single. B. S. in M. E., 1925, two years graduate work in Electrical Engineering. Desires instructorship in a college to teach Electrical Engineering subjects, mathematics or as Junior Engineer with an operating company. Available immediately. Location, immaterial. C-4153.

ELECTRICAL ENGINEER, 32, married, college graduate with five years' experience in power plant and sub-station design and city distribution; also three years electrical contracting and estimating; available on three weeks' notice. Location, New York City, preferably with small firm. C-950.

ELECTRICAL ENGINEER, 28, single, one year Westinghouse Test Course, two and one-half years with a Public Utility, desires to change position to one where his experience will be of value and with prospects of opportunity after ability has been proven. C-890.

ELECTRICAL ENGINEER, American, healthy, active and qualified by education, experience and ability to discharge the duties of general manager; at present holding position as works manager in plant employing three hundred hands, manufacturing electrical power apparatus, alternating and direct current motors and generators, transformers, switchboards and control apparatus. Desires similar position. C-4206.

ASSISTANT TRANSMISSION OR DISTRIBUTION ENGINEER, 26, married. 1923 graduate; 16 months Westinghouse Test; 18 months Distribution Engineering, making maps and records, tests and investigations, revamping and new overhead layouts; 20 months Engineering Department, planning extensions, electrical calculating, estimating budget and tax work. Location, East. C-3694.

MECHANICAL ENGINEER, 45, married, with successful executive and sales management experience. Desires connection with an established company of repute as sales representative or manager, or in an executive capacity. Satisfactory references as to character, ability and successful record of achievements are available. Location preferred, Metropolitan Boston or New England. A-2112.

ASSISTANT EXECUTIVE-ADMINISTRATIVE ENGINEER, 36, married. Well balanced experience fifteen years covers: industrial surveys, cost analyses, commercial statistics, advertising and administrative control. Seven years large company servicing subsidiaries and clients. Public utility experience. Prefers administrative or commercial to strictly technical. Location, New England, New York. B-9122.

POWER PLANT ENGINEER, 24, single. Recent graduate, 1927, Electrical Engineer would work hard if given position with public utility in United States or South America. Desires experience and opportunity for advancement. Good references. Location preferred, South America. C-2985.

GRADUATE ELECTRICAL ENGINEER with ten years' experience in central-station, substation, and power-transmission engineering, including construction, computation and design. Is qualified to take entire charge of such projects. Wishes to make a connection where hard work and ability will be recognized. C-3296.

ELECTRICAL ENGINEER, 26, married, 1920 graduate. 1¼ years' testing experience Western Electric; 4 years teaching industrial electricity; familiar with wiring methods, motor repair work and radio business. Available June 15th, will consider summer position or permanent position with future. Location preferred, East. B-3781.

RECENT GRADUATE, 22, single, of electrical engineering department of recognized technical college, desires employment with industrial concern as service or maintenance engineeer. Location preferred, West. C-4137.

ELECTRICAL ENGINEER, 25, single. Technical graduate, has had experience at practical electrical work. Reliable, industrious, pleasing personality, willing to learn. Does not expect large salary, but desires work of a technical nature with good chances for advancement. C-4220.

ELECTRICAL ENGINEER, 25, single, protestant; B. S. in E. E. graduate; 18 months General Electric test; 4 months field research work on power equipment; 21 months system operating for large New York State public utility. Desires change to position with opportunity for advancement. Location preferred, United States or Canada. C-4182.

ELECTRICAL ENGINEER, graduate of Massachusetts Institute of Technology, 1924. Experience with large public utility company in engineering division of the commercial department; duties including preliminary design, estimating and coordination of engineering and

construction on industrial customer's substations, changeover and new business. Desires similar or power sales position with large Eastern utility. B-9077.

CONSTRUCTION ENGINEER, 29, married. Three years' college, 5½ years' experience in power plant, indoor and outdoor substation construction; one year pole transmission line, some distribution. Can take charge of construction. Desires permanent connection. Location preferred, Southeast, South, Middlewest or Foreign. C-4164.

GENERAL FOREMAN, 30, married, desires position with assured advancement as reward for maximum application and energy. Ten years' utility experience as utility man, collector lineman, mechanic, foreman and general foreman of construction, maintenance and operation, transmission and distribution. High School education. Can establish good relations with public and employees. C-4110.

EXECUTIVE ENGINEER OR MANAGER AVAILABLE IMMEDIATELY, 39, married. Lifetime of general utility experience in above average responsibilities. Last five years executive staff 300 in three-quarter million meter property, developing seven million dollars construction annually. Familiar all types of problems. Prefer industrial connection affording opportunity of later buying interest. C-3963.

INSTRUCTOR-ELECTRICAL ENGINEER, 29, single, graduate, three years instructing electrical machinery; six summers' experience commercial and experimental tests electrical machinery, design, analysis, transmission, railway shop electrician, power, light engineering. Fifteen months' steel mill electrician; thirteen months draftsman electrical department of steel mill. Desires to teach electrical machinery or superintend electrical department steel plant or other large operating company. C-4248.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, 33, married; also two years post graduate work in Physics. Six years development, design, supervision of construction automatic electrical devices. Last five years development, research high tension special equipment. Some work X-rays. Patents granted and pending. Qualified as consulting, designing or research engineer, where experience and training can be used to best advantage. B-9406.

DRAFTSMAN, with four years' shop training and four years' drafting experience in Locomotives, desires position in power plant design; salary $140. Location, Philadelphia. C-2837.

ELECTRICAL SALES ENGINEER, 38, married. Yale graduate, 12 years with public utilities as sales engineer. Industrial maintenance and construction experience. Steel mill experience for seven years. Desires sales work with some traveling. Location, New York. C-3093.

ASSISTANT EXECUTIVE, 35, married, A. B. and B. S., Massachusetts Institute of Technology. Desires connection with industrial or commercial organization. Chemical and electrical training. Ten years' experience in experimental development of electrochemical products. At present holds responsible position in large technical organization. C-4243.

ELECTRICAL ENGINEER as technical assistant in management problems. Graduate engineer, 25, married, 4½ years' varied experience; General Electric Test; construction, maintenance, inspection and design on heavy electric traction equipment. Broad experience in industrial applications of electrical machinery. Business training. C-1048.

ELECTRICAL ENGINEER, technical graduate, experienced in power plant design, meters, distribution wiring, applications of light and power, water power and semi-Diesel, construction of small plant and all types of maintenance. Prefer design, construction or maintenance. At present in business, will go anywhere. B-9007.

SALES ENGINEER OR MANAGER, 37, married. Ten years' experience selling central station highly technical apparatus, experienced on high tension apparatus. Very wide acquaintance. Has had experience in manufacturing and design. Location, Philadelphia. C-2764.

DISTRIBUTION ENGINEER, 26, married, B. S. in E. E. Four years' experience in plant in distribution work, latter including design, estimating, supervision of construction and maintenance of systems of 13 KV and under. Also investigations and valuation of electrical systems. C-4247.

ELECTRICAL ENGINEER EXECUTIVE, married; twenty years' experience in design, construction and operation of power plants, substations and transmission systems. Prepared specifications, reports and estimates on electrical construction work. Have had full supervision of designing of power and industrial plants. Made various improvements in plant operations. Recently received distinguished honors for important work. B-3954.

ELECTRICAL MECHANICAL ENGINEER, technical graduate, desires connection with contracting or consulting engineering firm contemplating forming an electrical department. Experienced in power and substation design and industrial engineering. C-1141.

ELECTRICAL ENGINEER, 41, married, Scandinavian, graduate of technical college, B. S., 9 years in United States. Varied experience in design of electrical and mechanical apparatus. Capable of developing ideas. Also experienced in power houses and substations. Thorough education, knows several languages, including Spanish. Willing to travel but work along theoretical lines preferred. C-216.

GRADUATE ELECTRICAL ENGINEER, 27, single. Five years' experience in transmission and substation construction in the west; eight months in industrial plants. Desires position along engineering lines, and opportunity for permanent employment. Location, immaterial. C-3564.

ELECTRICAL ENGINEER, 35, married. University graduate. 14 years' industrial and mining electrification including design, construction, maintenance. Past three years designing complete electrification for cement plants. Experience covers power plants, substations, distribution and latest control equipment. Seeks permanent connection with large operation. B-9113.

RESEARCH ENGINEER, graduate Electrical Engineer with twenty years' experience covering a wide range of manufacturing and utility work, in shop, laboratory; drafting and design of small electrical and mechanical devices. Investive and resourceful. Desires connection with a growing industry of sound principles, to take charge of research or developmental engineering. C-1867.

ELECTRICAL ENGINEER. Graduate of Illinois, E. E., 1925. Experience in drafting, specification writing, and industrial teaching, telephone circuits and theory. Two and one-half years' experience in telephone development work with Bell Telephone Laboratories. Qualified to do research and development work in radio and allied fields. C-4232.

ELECTRICAL ENGINEER desires connection leading to executive or managerial duties. Technical graduate; has had successful experience in organizing nationwide engineering service; training would qualify for service in lines other than electrical. B-122.

ELECTRICAL ENGINEERING GRADUATE, 23, single. One year General Electric Test, including railway controls and automatic substation equipment. One year radio concern. Desires work on steam railroad electrification or with electric railroad. C-4241.

COLLEGE TRAINED ENGINEER, with years of experience in meter department work, who welcomes present conditions because they enable him to do best work; in search of a big, back-breaking opportunity. When he finds it, he has to offer knowledge and experience, an energetic and forceful personality and a single mind devoted to the best interest of his employer. C-4229.

ELECTRICAL ENGINEER, 30, married, desires position with Public Utility, consulting firm where there is opportunity for advancement. 1½ years General Electric Test; 3 years' experience in design of industrial control apparatus. Wide knowledge of application of control. At present employed, available one month. Excellent references. Location, New York, New Jersey, Southern New England. C-4263.

CHIEF ELECTRICIAN, ASSISTANT TO PLANT ENGINEER. Five year apprenticeship factory course. Thorough electrical, mechanical training. Efficient department organizer, accustomed handling men. Ten years supervision maintenance, new construction, 20,000 H/P industrial plant. Expert winder A. C. and D. C. motors, generators; transformers. Desires position industrial organization, public utility, electrical department of machinery insurance, or or sales department. United States, foreign. C-4249.

SENIOR of the graduating class of Massachusetts Institute of Technology, taking the Electrical Engineering Course would like a position on the sales force of a company selling or manufacturing electrical apparatus. Position in the eastern part of United States preferred. C-4253.

GRADUATE ELECTRICAL ENGINEER, University of Washington, 1925, 30, single. Experience: 1 year Public Utility; 1½ years Hydro Electric Construction; 1½ years General Electric Test, 1 year General Electric design and construction foreman experience in steel mills and coal mines; 2 years electrical design, mapping and construction. C-2290.

ELECTRICAL ENGINEER, 28, married, technical graduate, 6 years' experience test supervision with A. C. public utility, one years' teaching experience, executive, statistician, organizer. Desires position with progressive organization offering reasonable advancement for conscientious, energetic worker. C-1346

ELECTRICAL ENGINEER, 34, single, degree E. E.; desires position with engineering concern or public utility requiring executive ability. Ten years' experience covering engineering, design and valuation of power plants, substations, transmission and distribution lines. Location, East. B-389.

ASSISTANT TO EXECUTIVE, 28, married, graduate of Massachusetts Institute of Technology, Electrical Engineering. Two years shop and sales office, large electrical manufacturer. Two years assistant job engineer, firm of consulting engineers. Two years purchasing agent, same firm. Capable of handling responsible work independently. Location, New York City or New England but not restricted. C-3912.

SALES ENGINEER, 37, married; 14 years' engineering sales, General Electric Test, General Electric Engineering Department. Have handled successfully business contacts with the highest executives on Public Utilities, which has given confidence and the moral background to meet any requirements. Interested only in connection where income will be $6500 per year. C-4271.

GRADUATE ELECTRICAL ENGINEER, single. Graduate of Armour Institute of Technology. One years' experience in electrical utility student course, covering generation, distribution, street, and contract departments; three months with budget section of large utility. Desires to transfer to engineering or research with utility or manufactory. Location, immaterial; United States or foreign. C-3822.

GRADUATE ELECTRICAL ENGINEER with twenty years' experience; last seven as superintendent of hydroelectric, rotary converter, and mill electrical equipment, installations, operation and maintenance; capable organizer, experienced in handling men. Desires position with large manufacturing concern or public utility as electrical superintendent, engineering manager or in engineering department with

opportunity for advancement along executive lines. C-4013.

EXECUTIVE ENGINEER, qualified to supervise planning, design, construction, maintenance and investigations of industrial and utility plants and equipment, office building equipment installations; also to improve power supply and utilization, the arrangement of manufacturing machinery and equipment to produce increased and improved output of product at lower unit and total costs. B-5552.

GRADUATE ELECTRICAL ENGINEER, 41, married; 17 years' practical electrical and mechanical experience in powerplants, substations, transmission and distribution, industrial and lighting installations; layout, estimating and field. Also practical, scientific research and development experience. Location, New York City. B-8609.

ELECTRICAL ENGINEER, technical graduate experienced in development, design and manufacture of instruments and small electrical apparatus. Expert in standardizing such products for commercial manufacture. Developing and planning new methods and processes, inspections and tests. Experienced executive thoroughly familiar with modern factory organization and administration. American born Christian. B-2721.

MEMBERSHIP — Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held March 21, 1928, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

CLOKEY, ALLISON A., Telegraph Engineer, Bell Telephone Laboratories, New York.

To Grade of Member

CROFOOT, CLARENCE E., Head of Elec. Dept. and Acting Head of Technical High School Division, Utica Free Academy, Utica, N. Y

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates, should so inform the Secretary before April 30, 1928.

Abrahamson, H. B., Northern States Power Co., St. Paul, Minn.
Adache, W., Detroit Edison Co., Detroit, Mich.
Allen, D. B., Southern California Edison Co., Alhambra, Calif.
Baker, R. M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Ballenger, W. M., General Electric Co., St. Louis, Mo.
Barley, L. A., Mountain States Inspection Bureau, Denver, Colo.
Beatty, H. M., Dingle-Clark Co., Cleveland, Ohio
Berend, L., Rochester Gas & Electric Corp., Rochester, N. Y.
Beyer, G. W., General Electric Co., Buffalo, N. Y.
Block, M. G., New York Telephone Co., New York, N. Y.
Blum, E., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Bockmann, H., Electrical Management & Engineering Corp., New York, N. Y.
Boyd, S. W., with Robert S. Newcomb, Atlanta, Ga.
Brandon, M. M., Underwriters Laboratories, Inc., Chicago, Ill.
Brisbin, W. J., Western Electric Co., Pittsburgh, Pa.
Brossman, C., (Member), Cons. Pr. & Utility Plant Engr., Indianapolis, Ind.
Bruce, J., Southern California Edison Co., Long Beach, Calif.
Buchanan, J. C., Warner Service Co., Knoxville, Tenn.
Bullock, H. S., Hawley Pulp & Paper Co., Oregon City, Ore.
Burkholder, R. R., Westinghouse Elec. & Mfg. Co., Philadelphia, Pa.
Burley, J. G., Hydro-Electric Power Commission Labs., Toronto, Ont. Can.
Cadenas, F. J., (Member), National Lamp Works, G. E. Co., New York, N. Y.
Campbell, J. C., Carlisle & Finch Co., Cincinnati, Ohio
Carmichael, J. J., Independent Elec. Machinery Co., Kansas City, Mo.
Carson, J. P., Graybar Electric Co., Spokane, Wash.
(Applicant for re-election.)
Cawson, W. F., Public Service Co. of No. Illinois, Waukegan, Ill.
Chabot, A. J., General Electric Co., Schenectady, N. Y
Cooley, W. G., Illinois Power & Light Co., Granite City, Ill.
Connor, C. A., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Costigan, J. P. McD., Shawinigan Water & Power Co., Montreal, P. Q., Can.
Cottrell, B. P., Mass. Inst. of Technology, Cambridge, Mass.
Crandall, E. L., General Electric Co., Schenectady, N. Y.
Crawford, C. G., Utica Mining Co., Angels Camp, Calif.
Crawford, W. E., (Member), A. O. Smith Corp., Milwaukee, Wis.
Davison, G. W., General Railway Signal Co., Rochester, N. Y.
Dawson, C. H., Pacific Tel. & Tel. Co., San Francisco, Calif.
Day, C. M., (Member), Bureau of Reclamation, Denver, Colo.
Donkersley, A. B., Westinghouse Elec. & Mfg. Co., New Haven, Conn.
Dorfer, H,. (Member), Electrical Engineer, New York, N. Y.
Duley, I., New York Edison Co., New York, N. Y.
Duryee, L. M., South County Public Service Co., Westerly, R. I.
Egan, J. F., K & B Electric Equipment Co., New York, N. Y.
Evans, D. C., Triumph Electric Corp., Carthage, Ohio
Ferguson, J. C., Hydro-Elec. Pr. Comm. of Ontario, Toronto, Ont., Can.
Fickel, L. V., Westinghouse Elec. & Mfg. Co., Denver, Colo.
Fies, J., Texas Power & Light Co., Dallas, Texas
Fletcher, H. J., Vermont Hydro-Electric Corp., Rutland, Vt.
Frank, H. E., A. C. Motor Service, Jersey City, N. J.
Gahnkin, V. G., (Member), Brooklyn Edison Co., Brooklyn, N. Y.
Garland, E. R., Triumph Electric Corp., Cincinnati, Carthage, Ohio
Godfrey, H. D., Rochester Telephone Corp., Rochester, N. Y.
Goff, C. L., Phoenix Utility Co., Allentown, Pa.
Gordon, J. H., Jr., (Member), New York Telephone Co., Brooklyn, N. Y.
Gray, T. S., Mass Institute of Technology, Cambridge, Mass.
Hagen, E., Niagara Electric Service Corp., Niagara Falls, N. Y.
Haglund, H. H., (Member), Western Union Telegraph Co., New York, N. Y.
Hall, N. A., Willis & Hall Electric Co., Regina, Sask., Can.
Hamilton, F. A., Jr., General Electric Co., Schenectady, N. Y.
Hartung, A. F., General Electric Co., Philadelphia, Pa.
Heineken, P., Public Service Production Co., Newark, N. J.
Herrick, R. W., General Electric Co., Providence, R. I.
Herzberger, F. H., Westinghouse Elec. & Mfg. Co., Denver, Colo.
Hogan, A. S., Northern States Power Co., St. Paul, Minn.
Holmes, M. L., Commonwealth Edison Co., Chicago, Ill.
Holthaus, H. B., Illinois Power & Light Corp., East St. Louis, Ill.
Houghton, H. M., New York Central Railroad, Harmon, N. Y.
Hovland, H., (Member), Bell Telephone Laboratories, New York, N. Y.
Howell, J. O., Railroad Commission, State of Calif., San Francisco, Calif.
Hughes, R. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Hussey, S. R., Columbia Engineering & Management Corp., Cincinnati, Ohio
Johnson, A., Brooklyn Edison Co., Brooklyn, N. Y.
Johnston, D. H., Jr., (Member), Cons. Gas, Elec. Lt. & Pr. Co., Baltimore, Md.
Jones, F. L., Electric Controller & Mfg. Co., New York, N. Y.
Keil, M. T., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Kirsch, C. F., William H. Ludwig, Brooklyn, N. Y.
Koch, M. R., Electric Power & Equipment Co., Columbus, Ohio
Koch, P. W., Paul W. Koch Co., Chicago, Ill.
Komnenos, N. A., Washington University, St. Louis, Mo.
Lacerte, W. J., Bell Telephone Laboratories, New York, N. Y.
Lancto, J. W., Hartford Electric Light Co., Hartford, Conn.
Landesberg, M. M., Landesberg Engineering Co., Brooklyn, N. Y.
La Pierre, C. W., General Electric Co., Philadelphia, Pa.
Larson, M. N., Public Service Co. of No. Illinois, Waukegan, Ill.
Lindsay, J. B., Leeds & Northrup Co., Philadelphia, Pa.
Luckett, A. F., Rochester Gas & Electric Corp., Rochester, N. Y.
Mac Lean, T. W., Washington Water Power Co., Spokane, Wash.
Mallina, R. F., (Member), Victor Talking Machine Co., Camden, N. J.
Manning, O. R., Illinois Power & Light Corp., Granite City, Ill.
Marsters, F. H., Mutual Telephone Co., Erie, Pa.
Martin, C. A., The Dingle-Clark Co., Cleveland, Ohio
McCarthy, F. E., New York Telephone Co., Albany, N. Y.
McInturff, R. H, (Member), General Electric Co., Dallas, Texas
Mendenhall, J. W., Mount Spokane Power Co., Deer Park, Wash.
Mittman, C. F., 1663 First Ave., New York, N. Y.
Nagle, R. F., Union Switch & Signal Co., Swissvale, Pa.

Neff, E. N., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Nelson, A., Westinghouse Elec. & Mfg. Co., Minneapolis, Minn.
Nemetz, D., Dominion Electric Power Co., Gravelbourg, Sask., Can.
Peterson, J. E., 8441 85th Road, Woodhaven, N. Y.
Petrie, A. E., Illinois Bell Telephone Co., Chicago, Ill.
Quinn, N. W., Production Magazine; Electrical League of Cleveland, Cleveland, Ohio
Ransom, G. B., American Tel. & Tel. Co., Cleveland, Ohio
Reves, L., Atmospheric Nitrogen Corp., Syracuse, N. Y
Rice, C. N. Jr., with Albert S. Richey, Chattanooga, Tenn.
Richardson, B. P., Jr., U. S. N. R., V. J. Squadron 2S, c/o Postmaster, N. Y.
Rider, J. F., Advertising, 270 Madison Ave., New York, N. Y.
Riley, G. A., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
(Applicant for re-election.)
Robertson, J. G., Jr., Union Electric Co., Webster Groves, Mo.
Roch, L. J., Dept of City Transit of Philadelphia, Philadelphia, Pa.
Rozeboom, R. A., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Schuler, R. G., State Line Generating Co, Chicago, Ill.
Schultze, C. O., Lehigh Valley Railroad Co., Buffalo, N. Y.
Schwarze, K., University of Santa Clara, San Jose, Calif.
Sciotti, F., Rhode Island Electric Protective Co., Providence, R. I.
Shaheen, S., Public Service Electric & Gas Co., Metucheon, N. J.
Simpson, W. F., Bell Telephone Laboratories, Inc., New York, N. Y.
Smith, A. L., (Member), U. G. I. Contracting Co., Devon, Conn.
Smith, J. Y., (Member), Atmospheric Nitrogen Corp., Syracuse, N. Y.
Smith, W. M., Eastern Mass. Electric Co., Salem, Mass.
Stannard, S. C., Ingersoll-Rand Co., Denver, Colo.
Steiger, B. F., Oxweld Acetylene Co., Newark, N. J.
Stevens, W. P., Texas Power & Light Co., Dallas, Texas
Strong, H. D., General Electric Co., Los Angeles, Calif.
Sykes, L. W., (Member), Western Electric Co., Denver, Colo.
Tarajano, G. A., Columbia University, New York, N. Y
Thiele, L. E., Postal Telegraph-Cable Co., Dallas, Texas
Thoma, A. J., New York Telephone Co., New York, N. Y.
Thomas, F. B., (Member), Victor American Fuel Co., Denver, Colo.
Tucker, W. E., Jr., Mass. Inst. of Technology, Cambridge, Mass.
Van Wagner, P., (Member), Copperweld Steel Co., New York, N. Y.
Vaughan, H. L., Mountain States Machinery Co., Denver, Colo.
Volck, A. G., (Member), Cecil de Mille Picture Corp., Culver City, Calif.
Walters, C. F., New York Telephone Co., Brooklyn, N. Y.
Ward, C. A., Electrical Bureau, Paterson, N. J.
Willcox, B. W., General Electric Co., Buffalo, N. Y.
Wolf, C. W., Square D. Co., Detroit, Mich.
Wolfe, H. C., Chromium Corp. of America, Cleveland, Ohio.
Wrasman, J. J., Electric Controller & Mfg. Co., Cleveland, Ohio
Total 138.

Foreign

Burns, P. L., (Fellow), Queen's Univ.; Municipal College of Technology, Belfast, Ireland
Collier, A. C., Durban Corp., Durban, Natal, S. Africa
Elphick, E. de B., Madras Electric Supply Corp., Ltd., Vepery, Madras, India
Jain, C. L., Power House, Bharatpur, Rajputana, India
Ohkubo, T., Nihon Denryoku K. K Kitaku, Soje-Cho, Osaka, Japan
Uno, S., Tokyo Electric Light Co., Ltd., Sakuradahongo-Cho, Shiba-kee, Tokyo, Japan
Wilson-Rae, J. R., Westinghouse Elec. & Mfg. Co., Buenos Aires, Arg. Rep., So. Amer.
Yagi, H., (Member), College of Engg., Tohoku Imperial University, Sendai, Japan
Total 8.

STUDENTS ENROLLED

Abrahamson, Arthur L., University of Minnesota
Abrahamson, LeRoy M., Jr., Univ. of Minnesota
Adams, Crawford, M., University of Vermont
Alberi, Albert, New York University
Alsing, Carl F., Worcester Polytechnic Institute
Alspaugh, Raymond M., University of Kansas
Anderson, Arnold O., University of Minnesota
Anderson, Elmer A., Case School of Applied Science
Bailey, Loren A., Louisiana State University
Baldock, Carroll M., Virginia Polytechnic Inst.
Bancroft, Herman, Northeastern University
Bartels, Arnold T., University of Wisconsin
Baunsgard, Lee A., University of Washington
Beckham, Benjamin M., Jr., Virginia Poly. Inst.
Bodman, John M., State College of Washington
Bohrer, Donald M., University of Minnesota
Bonzi, Febo, University of California
Borchardt, L. F., University of Minnesota
Boyer, James B., Pennsylvania State College
Brader, Ralph A., Newark College of Engineering
Braum, Cyril M., University of Minnesota
Brennecke, Cornelius, Columbia University
Brinsko, George M., University of Pittsburgh
Brooks, Clifton J., Case School of Applied Science
Brumback, Fred I., Virginia Polytechnic Inst.
Bryant, Carlton F., Pennsylvania State College
Burn, Edward M., Georgia School of Technology
Burton, Walter A., Virginia Polytechnic Institute
Cahn, Harold, University of Minnesota
Caldwell, Richard A., Calif. Institute of Tech.
Campbell, Richard L., Iowa State College
Capron, Robert B., Columbia University
Carnevale, Oscar A., Brown University
Casper, Charles L., University of Louisville
Cherry, Carlton E., University of California
Chin, Luther, Q. H., Worcester Poly. Inst.
Clarenden, Charles H., Jr., Newark Col. of Engg.
Coit, Frank R., University of California
Cooper, Thomas R., West Virginia University
Cowles, Laurence G., University of Vermont
Crosby, Frank A., University of California
Crosby, William L., Worcester Polytechnic Inst.
Darnielle, Robert B., University of Minnesota
Darrah, Charles C., Virginia Polytechnic Inst.
de La Torre, Juan B., Engg. School of Milwaukee
Deming, Paul S., Oklahoma A. & M. College
Dempster, William B., University of California
DeVoy, William T., University of Minnesota
Dickie, Alexander M., University of California
Dickinson, Arthur H., Union College
Dorow, Ernest W., University of Pittsburgh
Downs, Eugene F., Worcester Polytechnic Inst.
Doyle, Rhederick E., Jr., Virginia Poly. Inst.
Drgon, John A., University of Pittsburgh
Dybvig, Edwin S., University of Minnesota
Eckstein, A. Joseph, University of Wisconsin
Edey, F. E., University of Minnesota
Eglit, William F., Brooklyn Polytechnic Inst.
Eliasen, Eilert J., University of Washington
Elliott, Carroll L., University of Minnesota
Ellison, Huyler B., Mass. Institute of Technology
Evans, Samuel, University of Louisville
Fansler, Bender I., Virginia Polytechnic Inst.
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Relays.—Bulletin AE-550. Describes a wide variety of relays for numerous applications. Roller-Smith Company, 12 Park Place, New York.

Motors.—Bulletin 1118-E, 16 pp. Describes types AR and ARY polyphase induction motors, which are the Allis-Chalmers squirrel cage and slip-ring type, general purpose motors. The bulletin lists both the slip and roller bearing types and in standard horizontal and vertical construction. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Motors.—Bulletin 151, 8 pp. Describes a new line of Wagner air-jacketed motors for use where dust, fumes and moisture are prevalent. The motors are new in external construction only, no changes having been made in the electrical principles of the machines. The frame housing, the motor proper and all bearings are substantially air-tight. They are equipped with double row ball bearings. The Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Mo.

Motors.—Bulletin 200-B, 26 pp. Describes "Linc-Weld" induction motors for two- and three-phase alternating current. The manufacturer claims the distinction of being the only one to produce a steel motor and that the "Linc-Weld" process has made possible long sought for improvements in the rotor, the oiling system, and the ventilation. The processes of manufacture are illustrated in the bulletin. The Lincoln Electric Company, Cleveland, Ohio.

Watthour Meters.—Bulletin 67, (supplement), 8 pp. Describes the Sangamo type HC meter, fully compensated at all temperatures under all conditions of load. According to the bulletin, the most remarkable feature of this engineering achievement is the fact that such improved performance under all conditions of service has been obtained without any fundamental change in mechanical or electrical design of the type H, which was brought out in 1914. The Sangamo Electric Company, Springfield, Ill.

Cable-Pulling Compound.—Bulletin 120, 6 pp. Describes a new cable-pulling lubricant which, according to the manufacturer, has been thoroughly tested and found to be ideal for this purpose. The saving in time and labor on a job, and the saving of wear and tear on the cable itself are its chief recommendations. The new compound requires far less application in quantity than either soapstone or grease, and moreover, adheres to the sheath of the cable, insuring lubrication throughout the entire duct. Minerallac Electric Company, 1045 Washington Boulevard, Chicago, Ill.

NOTES OF THE INDUSTRY

Schweitzer & Conrad, Inc., Chicago, announces the appointment of J. Leo Scanlon as the company's New York City correspondent at 50 Church Street.

The Sterling Varnish Company has removed its general office from the Fulton Building, Pittsburgh, to its new office building at Haysville, Penn., thus consolidating the sales, purchasing and engineering divisions with the plant.

The Delta-Star Electric Company, Chicago, has opened a new Kansas City, Missouri, office in charge of L. C. Hitzeroth, who has been transferred from the sales engineering division of the Chicago factory.

The Copperweld Steel Company, Glassport, Penn., has appointed Paul Van Wagner as representative for the Pittsburgh district, in charge of central station and railroad sales, covering the distribution of Copperweld products in western Pennsylvania, western Virginia, western Maryland and the state of West Virginia.

The Cutter Company Changes Its Name.—The Cutter Electrical & Manufacturing Company, of Philadelphia, manufacturers of I-T-E circuit breakers and U-Re-Lites for forty years, has changed its name to the I-T-E Circuit Breaker Company. The policies, personnel and products of the I-T-E Circuit Breaker Company remain the same as those of the old company.

The National Carbon Company, Inc., has moved its branch sales office and factory of the Carbon Sales Division from 357 West 36th Street, New York, to new and much larger quarters at the company's plant at 14th and Henderson Streets, Jersey City. The change more than doubles the size of the former plant, and considerable additional manufacturing equipment has been added to meet the increasing demands for the company's brushes and carbon products in the Eastern district territory.

Standard Underground Cable Company, Division of General Cable Corporation has announced that A. B. Saurman formerly vice-president and general sales manager has been made vice-president and consulting general sales Manager and will continue his headquarters at the general offices in Pittsburgh, upon his return from the South where he has been for some time on account of ill-health. Harold P. Childs has been made general sales manager. He was previously with the General Electric Co., and the Servel Corporation.

High Voltage Circuit Breakers.—The General Electric Company has just completed the design of a new line of outdoor oil circuit breakers. This new line is designated as the F (H) K (O)-139 type with interrupting capacities ranging from 350,000 kv-a. to two and a half million kv-a. These breakers are built in voltage sizes from 15,000 to 220,000 volts.

Commutator Stones.—The Martindale Electric Company, 1254 West 4th Street, Cleveland, Ohio, announces a new "Double Duty" commutator stone for touching up commutators and slip rings. One end is made from a coarse (cutting) grade and the other end from a fine (finishing) grade. These stones are furnished in various sizes for convenience in carrying in the pocket or tool kit.

Microammeter.—The Rawson Electrical Instrument Company, Cambridge, Mass., has developed a new portable calibrated instrument reading down to excessively small current values. This is the type 503, semi-suspended meter, where a full scale of sensitivity is obtained with a current of 0.5 microampere or .0000005 ampere, the scale being approximately five inches long, divided into 100 divisions, each division representing .005 microampere.

Vitreosil for Electrical Purposes.—The Thermal Syndicate, Ltd., 58 Schenectady Avenue, Brooklyn, announces that improved processes lately developed at its English factory have resulted in the production of a number of new products in vitreosil of especial interest to electrical engineers, samples of which will be supplied upon request. These include glazed bushings with heavy walls of regular thickness in a variety of diameters and lengths; drawn shapes, hollow or solid strips of various cross-sections; capillary tubing, single or multiple bore, in the clear or opaque grades, to close specifications. The company's bulletin "About Vitreosil" describes some of the outstanding characteristics of this material.

G-E Earnings in 1927.—Earnings of the General Electric Company for 1927 amounted to $48,799,488, equivalent, after dividends on the special stock, to $6.41 a share on the 7,211,481 shares of no par common stock, the annual report of the company made public several days ago by President Gerard Swope, disclosed. This compares with $6.14 a share in 1926.

Orders received during the year 1927 were $309,784,623, compared with $327,400,207 in 1926 a decrease of 5 per cent, and unfilled orders at the end of the year were $68,916,000, compared with $72,297,000 at the close of 1926, also a decrease of 5 per cent.